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VOLUME 1 SUMMARY

1 SEPTEMBER 1965

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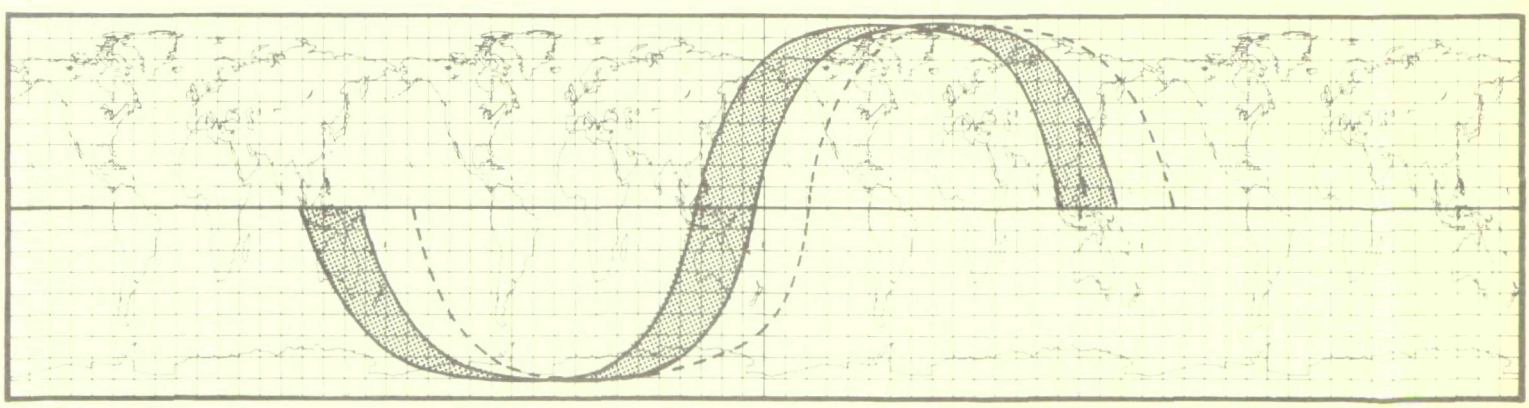

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GENERAL ELECTRIC COMPANY
DAYTONA BEACH, FLORIDA

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ALTERNATE APOLLO MISSION DESCRIPTIONS (U)

VOLUME 1

SUMMARY

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Apollo Support Department
General Electric Company
Daytona Beach, Florida

PREFACE

This document is the summary volume of the final report of analyses conducted and mission descriptions developed by the Apollo Support Department of General Electric Company under Contract NASw-410 for the National Aeronautics and Space Administration. The report was written in accordance with the requirements of Paragraph B4.3.4 of the Work Statement and NASA Headquarters Technical Direction Memorandum TD B4-2.

TABLE OF CONTENTS

Paragraph	Title	Page
	SECTION 1 - ALTERNATE APOLLO MISSION DESCRIPTIONS	
1.1	MISSION 1 - INTERMEDIATE INCLINATION SURVEY	1-3
1.1.1	EXPERIMENTS	1-3
1.1.2	CONFIGURATION	1-3
1.1.3	TRAJECTORY	1-4
1.1.4	OPERATIONS	1-4
1.1.5	CREW ACTIVITIES	1-5
1.1.6	DATA FLOW	1-6
1.2	MISSION 2 - SATURN IB TO SATURN IB RENDEZVOUS	1-15
1.2.1	EXPERIMENTS	1-15
1.2.2	CONFIGURATION	1-17
1.2.3	TRAJECTORY	1-17
1.2.4	OPERATIONS	1-18
1.2.5	CREW ACTIVITIES	1-19
1.2.6	DATA FLOW	1-21
1.3	MISSION 3 - SYNCHRONOUS OBSERVATION POST	1-31
1.3.1	EXPERIMENTS	1-31
1.3.2	CONFIGURATION	1-32
1.3.3	TRAJECTORY	1-32
1.3.4	OPERATIONS	1-33
1.3.5	CREW ACTIVITY	1-34
1.3.6	DATA FLOW	1-36
1.4	MISSION 4 - NEAR-POLAR RETROGRADE SURVEY	1-43
1.4.1	EXPERIMENTS	1-43
1.4.2	CONFIGURATION	1-44
1.4.3	TRAJECTORY	1-44
1.4.4	OPERATIONS	1-44
1.4.5	CREW ACTIVITY	1-45
1.4.6	DATA FLOW	1-46

TABLE OF CONTENTS (Cont.)

Paragraph	Title	Page
1.5	MISSION 5 - SATURN V TO SATURN IB RENDEZVOUS	1-55
1.5.1	EXPERIMENTS	1-55
1.5.2	CONFIGURATION	1-56
1.5.3	TRAJECTORY	1-57
1.5.4	OPERATIONS	1-58
1.5.5	CREW ACTIVITY	1-58
1.5.6	DATA FLOW	1-60
1.6	MISSION 6 - LEM SHELTER/TAXI MISSION	1-69
1.6.1	EXPERIMENTS	1-69
1.6.2	CONFIGURATION	1-70
1.6.3	TRAJECTORY	1-70
1.6.4	OPERATIONS	1-70
1.6.5	CREW ACTIVITY	1-71
1.6.6	DATA FLOW	1-72
1.7	MISSION 7 - LUNAR POLAR ORBIT SURVEY	1-79
1.7.1	EXPERIMENTS	1-79
1.7.2	CONFIGURATION	1-80
1.7.3	TRAJECTORY	1-80
1.7.4	OPERATIONS	1-80
1.7.5	CREW ACTIVITY	1-81
1.7.6	DATA FLOW	1-81

SECTION 2 - PROBLEM AREAS AND RECOMMENDATIONS

2.1	MISSION	2-3
2.1.1	TRAJECTORY	2-3
2.1.2	WEIGHTS	2-3
2.1.3	CONFIGURATION	2-3
2.1.4	DATA	2-3
2.1.5	CREW TASKS	2-4
2.2	MISSION 2	2-5
2.2.1	TRAJECTORY	2-5
2.2.2	WEIGHT	2-5
2.2.3	EXPERIMENTS	2-5

TABLE OF CONTENTS (Cont.)

Paragraph	Title	Page
2.2.4	CONFIGURATIONS	2-6
2.2.5	DATA	2-6
2.2.6	CREW TASKS	2-6
2.2.7	ABORTS	2-6
2.3	MISSION 3	2-7
2.3.1	TRAJECTORY	2-7
2.3.2	WEIGHT	2-7
2.3.3	CONFIGURATION	2-7
2.3.4	DATA	2-7
2.3.5	CREW TASKS	2-8
2.4	MISSION 4	2-9
2.4.1	TRAJECTORY	2-9
2.4.2	WEIGHTS	2-9
2.4.3	CONFIGURATION	2-9
2.4.4	DATA	2-10
2.4.5	CREW TASKS	2-10
2.5	MISSION 5	2-11
2.5.1	TRAJECTORY	2-11
2.5.2	WEIGHTS	2-11
2.5.3	CONFIGURATION	2-12
2.5.4	DATA	2-12
2.5.5	EXPERIMENTS	2-12
2.5.6	CREW TASKS	2-12
2.5.7	ABORTS	2-12
2.6	MISSION 6	2-13
2.6.1	TRAJECTORIES	2-13
2.6.2	WEIGHTS	2-13
2.6.3	CONFIGURATION	2-13
2.6.4	CREW TASKS	2-14
2.6.5	ABORTS	2-14
2.7	MISSION 7	2-15
2.7.1	TRAJECTORIES	2-15
2.7.2	WEIGHTS	2-15

TABLE OF CONTENTS (Cont.)

Paragraph	Title	Page
2.7.3	CONFIGURATION	2-15
2.7.4	EXPERIMENTS	2-16
2.7.5	DATA	2-16
2.7.6	CREW TASKS	2-16
2.7.7	ABORTS	2-16
	BIBLIOGRAPHY	Bib-1
	ACRONYMS AND ABBREVIATIONS	Bib-10

LIST OF ILLUSTRATIONS

Figure	Title	Page
1-1	Configuration History for the Intermediate Inclination Survey	1-9
1-2	Mission 1 Spacecraft Configuration and Experiment Location	1-11
1-3	Mission 1 - Launch, Mission Orbit Insertion and Re-entry Ground Trace	1-13
1-4	Mission 2 Configuration History	1-23
1-5	Spacecraft Experiment Configuration, Mission 2, Launch A	1-25
1-6	Spacecraft Experiment Configuration, Mission 2, Launch B	1-27
1-7	Mission 2, Vehicle A Launch, Mission Orbit Insertion and Re-entry	1-29
1-8	Rendezvous of Vehicles B and A	1-30
1-9	Mission 3 - Configuration History	1-37
1-10	Mission 3 - Spacecraft Configuration and Experiment Location	1-39
1-11	Launch and Mission Orbit Insertion Ground Trace	1-41
1-12	Re-entry Ground Trace	1-42
1-13	Cumulative Equatorial Orbital Surface Coverage Buildup in a Near-Polar Inclination	1-48
1-14	Mission 4 - Configuration History	1-49
1-15	Spacecraft Configuration and Experiment Location	1-51
1-16	Launch and Mission Orbit Insertion Ground Trace	1-53
1-17	Mission 5 - Configuration History	1-61
1-18	Spacecraft Configuration and Experiment Locations Flight A	1-63
1-19	Spacecraft Configuration and Experiment Location, Flight B	1-65
1-20	Mission 5 - Vehicle B Launch, Insertion, and Re-entry Trajectories	1-67
1-21	Location of Lunar Exploration Sites	1-73
1-22	Moltke B Exploration Site	1-75
1-23	Alphonsus Exploration Site	1-76
1-24	Mission 6 - Configuration History	1-77
1-25	Mission 6 - Configuration History	1-78
1-26	Lunar Site Locations	1-83
1-27	Mission 7 - Configuration History	1-85

INTRODUCTION

Under the technical direction of the National Aeronautics and Space Administration, the Apollo Support Department of General Electric Company conducted a series of analyses of Alternate Apollo Missions (AAM). The study consisted of the preparation of mission descriptions and supporting analyses to assess the compatibility and adequacy of mission planning elements.

The mission descriptions include mission objectives, ground rules, trajectories, configurations, flight operations, crew tasks, experiments, and spacecraft systems. The supporting analyses provided supplementary data on environments, data flow, expendable requirements, and other subjects necessary for mission description. In the study, NASA-furnished source documents were reviewed, correlated, and integrated. The result is a typical mission profile for each of the mission types prescribed by NASA as representative of the total program. The types are:

Mission 1 - Intermediate Inclination Earth Orbit Survey
Mission 2 - Saturn IB to Saturn IB Earth Orbit Rendezvous
Mission 3 - Synchronous Earth Orbit Observation Post
Mission 4 - Near Polar Retrograde Earth Orbit Survey
Mission 5 - Saturn V to Saturn IB Earth Orbit Rendezvous
Mission 6 - LEM Shelter/Taxi Lunar Surface Exploration
Mission 7 - Lunar Polar Orbit Survey

Brief characteristics of the missions are shown in Tables 1 and 2.

This report consists of four volumes:

Volume 1 - Summary
Volume 2 - Detailed Technical Report
Volume 3 - Technical Appendices
Volume 4 - Mission Planning Aids

This volume (Volume 1) summarizes the resultant mission descriptions, and identifies the planning-related problem areas for each of the missions. Recommendations also are included in this volume. A bibliography and a list of acronyms and abbreviations are appended.

Table 1

AAM Earth Orbit Missions (a)

Mission Number	1	2		3	4	5	
Mission Designation (a)	Intermediate Inclination Survey	SA-IB to SA-IB Rendezvous		Synchronous Observation Post	Near-Polar Retrograde Survey	SA-V to SA-IB Rendezvous	
Launch Vehicle	SA-IB	1st Launch SA-IB 2nd Launch SA-IB		SA-V	SA-V	1st Launch SA-V 2nd Launch SA-IB	
Mission Orbit Requirements							
Altitude (n. mi.)	200	200		19,350	200	200	
Inclination (degrees)	50	29.5 (48)		0	96.5	29.5 (48)	
Eccentricity	0 (Circular)	0 (Circular)		0 (Circular)	0 (Circular)	0 (Circular)	
Duration (days)	14	45 per spacecraft: 90 total		45	45	45 per spacecraft: 90 total	
Launch Data		1st SA-IB	2nd SA-IB			SA-V	SA-IB
Flight Assignment Number (46)	215	218	219	516	518	523	229
Launch Date (mo/yr) (1)	5/69	12/69	1/70	6/70	10/70	8/71	9/71
Launch Pad (7)	37B	34	37B	39A	39A	39B	37B
Crew Size (48)	3	3	3	3	3	3	3
Launch Geometry							
Launch Operations Description	2 Stages to 80-n. mi. Parking Orbit	2 Stages to 80-n. mi. Parking Orbit	2 Stages to 80-n. mi. Parking Orbit	3 Stages to 100-n. mi. Parking Orbit	3 Stages to Mission Orbit, Yaw Steering During S-IC and S-II Burns	3 Stages to 200-n. mi. Mission Orbit	2 Stages to 80-n. mi. Parking Orbit
AMR Launch Azimuth (degrees)	44	83 (C)	Variable	90	146	83 (C)	Variable
Parking Orbit Description					Not Applicable	Not Applicable	
Altitude (n. mi.)	80	80	80	100			80
Inclination (degrees)	50	29.5 (48)	Variable	28.5			Variable
Eccentricity	0 (Circular)	0 (Circular)	0 (Circular)	0 (Circular)			0 (Circular)
Insertion By	S-IVB	S-IVB	S-IVB	S-IVB			S-IVB
1st Transfer Trajectory					Not Applicable	Not Applicable	
Trajectory Type	Hohmann	Hohmann	Hohmann	Hohmann			Hohmann
Perigee Altitude (n. mi.)	80	80	80	100			80
Apogee Altitude (n. mi.)	200	200	200	19,350			200
Plane Change (degrees)	0	0	0	2 (48)			0
Inclination (degrees)	50 degrees	Coplanar	Coplanar	26.5 (48)			Coplanar
Insertion By	SPS	SPS	SPS	S-IVB			SPS
2nd Transfer Trajectory	Not Applicable	Not Applicable	Not Applicable		Not Applicable	Not Applicable	Not Applicable
Trajectory Type				Elliptic			
Perigee Altitude (n. mi.)				5,294 (48)			
Apogee Altitude (n. mi.)				19,350			
Plane Change (degrees)				17.4 (48)			
Inclination (degrees)				9.1 (48)			
Insertion By				S-IVB			
Mission Orbit							
Insertion By	SPS	SPS	SPS	SPS	S-IVB	S-II	SPS
Plane Change	0	0	0	9.1 (48)	0	0	0
Max. Wt. in Orbit (lbs)	30,929	33,185	33,185	61,441	122,974	210,667	33,185
Deorbit Planning Data							
Retro Fuel (lbs) (b)	794	810	824	14,554	861	824	824
Returnable S/C Deboost Weight (lbs)	20,664	21,057	21,421	35,119	22,432	21,421	21,421
Re-Entry							
Vacuum Perigee	0 (48)	0 (48)	0 (48)	26 ± 14 (29)	0 (48)	0 (48)	0 (48)
Recovery Site (24)	PRA (24)	PRA (24)	PRA (24)	PRA (24)	PRA (b)	PRA (24)	PRA (24)

Footnotes: (a) All information is from reference No. 19 unless otherwise noted.
(b) Retro Velocity impulse plus 10%.
(c) See Part I, Paragraph 2.2.5.

Table 2

AAM Lunar Missions (a)

Mission Number	6		7
Mission Designation	LEM Shelter/Taxi Mission		Lunar Polar Orbit Survey
	Shelter Delivery	Taxi/Exploration	
Launch Vehicles	SA-V	SA-V	SA-V
Launch Data			
Flight Assignment No. (46)	519	520	522
Launch Date (mo/yr) (1)	12/70	2/71	6/71
Launch Pad (7)	39B	39A	39A
Crew Size (48)	3	3	3
Launch Geometry			
Launch Operation Description	3 Stages to Earth Parking Orbit	3 Stages to Earth Parking Orbit	3 Stages to Earth Parking Orbit
Launch Azimuth (deg)	90	90	90
Earth Parking Orbit Description (24)			
Altitude (n. mi.)	100	100	100
Inclination (deg)	28 5	28.5	28.5
Inserted by	S-IVB	S-IVB	S-IVB
Translunar Trajectory			
Type (47)	Retrograde Non-free Return	Retrograde Non-free Return	Retrograde Non-free Return
Maximum Flight Time (hrs) (24)	110	110	110
Maximum Midcourse Corrections (24)	3	3	3
Maximum Injected Weight (lbs) (47)	95,000	95,000	95,000
Inserted by (24)	S-IVB	S-IVB	S-IVB
Lunar Parking Orbit			
Altitude (n. mi.) (47)	80	80	80
Inclination (deg)	Variable (48)	Variable (48)	90 (46)
Eccentricity (47)	0 (Circular)	0 (Circular)	0 (Circular)
No. of Plane Changes	0 (24)	0 (48)	0-3 (48)
Duration (days)	90 (48)	14 (46)	28 (46)
Inserted by (24)	SPS	SPS	SPS
Descent Trajectory			Not Applicable
Trajectory Type (24)	Hohmann	Hohmann	
Perigee Altitude (feet) (24)	50,000	50,000	
Apogee Altitude (n. mi.) (24)	80	80	
Inclination (deg) (48)	( )	( )	
Inserted by (24)	LEM Descent Engine	LEM Descent Engine	
Powered Descent			Not Applicable
Type	Automatic (47)	Automatic to Hover (24) Manual to Touchdown	
Landing Site	25° 20' E/1° 20' S (48)	25° 20' E/1° 20' S (48)	
Lunar Surface Operations			Not Applicable
Duration (days)	90 (1)	14 (46)	
Lunar Launch	Not Applicable		Not Applicable
Type		Automatic	
Plane Change Requirement		( ) (48)	
Parking Orbit	Not Applicable		Not Applicable
Altitude (feet) (24)		50,000	
Inclination (deg)		Coplanar with CSM	
Insertion by		LEM Ascent Engine	
Rendezvous Ascent Trajectory (24)	Not Applicable		Not Applicable
Type		Hohmann	
Perigee Altitude (feet)		50,000	
Apogee Altitude (n. mi.)		80	
Inclination (deg)		Coplanar with CSM	
Inserted by		LEM Ascent Engine	
Rendezvous and Docking Operations	Not Applicable		Not Applicable
Type (24)		Nominal Apollo	
Transearth Trajectory			
Maximum Flight Time (hrs) (24)	110	110	110
Maximum Midcourse Corrections (24)	3	3	3
Vacuum perigee (n. mi.) (29)	26 ± 14	26 ± 14	26 ± 14
Re-entry			
Recovery Site (24)	PRA	PRA	PRA

Footnote: (a) All information supplied by technical direction unless otherwise referenced.

SECTION 1

ALTERNATE APOLLO MISSION DESCRIPTIONS

The NASA program for the exploration of near-earth space and the moon provides the capability of performing the following space missions:

a. Up to 45-day missions in earth orbit.
   (1) Low altitudes, low inclinations.
   (2) Low altitudes, high inclinations, including polar orbits.
   (3) Synchronous orbital positions, equatorial and inclined.
   (4) Rendezvous of two separately launched spacecraft.

b. Up to 28-day mission in lunar orbit (plus transit time).
   (1) Equatorial and low inclination.
   (2) Polar and high inclination.

c. Up to 4-day lunar surface missions, using an unmanned LEM landing for logistics support of a separately launched manned LEM landing.

The AAM study developed an example of each mission type except the low inclination lunar orbit mission.

The principal assumptions used in preparing the mission descriptions are as follows:

a. Launch Vehicles. The Saturn IB and Saturn V launch vehicles are utilized. The Saturn IB launch profile includes injection into an 80-n. mi. parking orbit, after which, the Service Propulsion System (SPS) is used to attain mission orbit.

   The Saturn V profile for earth orbit missions injects the spacecraft directly into mission orbit, using all three launch vehicle stages. An exception is Mission 3, the equatorial synchronous orbit mission, which utilizes a 100-n.mi. parking orbit. The launch vehicle profile for lunar missions is the Apollo mission profile.

b. Spacecraft. The Mission 1 spacecraft is the NAA Block II Command and Service Modules (CSM), Modification I, and the GAEC Lunar Excursion Module Laboratory (LEM/LAB). The spacecraft configuration for other earth orbit missions are based on the NAA Block II CSM, Modification D, and the GAEC LEM/LAB.

The LEM/LAB consists of ascent and descent stages, but for earth orbit missions, the ascent and descent propulsion stages have been removed, displaced by experiment equipment. For lunar missions, the spacecraft configuration consists of the NAA Block II CSM, Modification C, and the GAEC LEM. Modifications to the LEM are based on specific mission requirements. A Launch Escape System (LES) and a Spacecraft LEM Adapter (SLA) are also provided for each launch.

c. Experiments. The experiment loads and weights for the earth orbit missions were defined by GAEC, and modified by Bellcomm to meet weight margins. The experiment loads for Mission 6, the LEM Shelter/Taxi mission, were defined by Bendix.

d. Ground Rules and Flight Operations. Mission ground rules and spacecraft flight operations descriptions were taken from the Apollo Design Reference Mission, as applicable.

A synopsis of each mission follows, containing a brief summary of the profile evolved by the AAM study. For further details of items in this summary, the detailed technical report, Volume 2, should be referenced. All source data is referenced in Volume 2, which provides thorough details of references and delineates revisions to source data. Source reference notes were excluded from this summary volume.

1.1 MISSION 1 - INTERMEDIATE INCLINATION SURVEY

An Apollo Block II CSM and a LEM/LAB manned by a crew of three will be placed in a nominal 200-n. mi. circular earth orbit at a 50-degree inclination. For 14 days, the crew, using experiment equipment aboard the LEM, will map the visible and near-visible spectra regions of the earth and conduct other experiments in manned survey techniques, bioscience, and space technology.

1.1.1 EXPERIMENTS

Six groups of experiments are planned for Mission 1: two groups examine the biomedical and behavioral characteristics of crew members; one group explores a prototype feasibility test of artificial gravity producing equipment; one group monitors radiation environment; two groups are intended to qualify remote sensing equipment and demonstrate manned survey techniques for mapping and acquiring multispectral signatures of minerals and vegetable/animal life. The experiments are as follows:

Experiment Number	Category
0100	Biomedical
0200	Behavioral
0301	Artificial-g
0501	Radiation Environment Monitoring
0901	Multispectral Target Characteristics
0902	Synoptic Earth Mapping

1.1.2 CONFIGURATION

The configuration history for the mission is shown in Figure 1-1. Mission times are provided in the figure, relating time to the configuration changes.

The experiment equipment includes optical sensors, a multispectral camera, 24-inch and 6-inch focal-length cameras, a grating spectrometer sensor, infrared-imager, microwave-imager and radiometer antennas, a VHF pulse antenna, and a mechanism that produces artificial gravity. The location of experiment equipment within the LEM/LAB is shown in Figure 1-2.

The total weight of experiment equipment is approximately 3300 pounds, of which more than half is attributed to earth mapping equipment. The equipment occupies 224 cubic feet, and requires an average power of 703 watts, with peaks to 1298 watts. Subtracting the payload weight of Mission 1 from the maximum allowable weight, the margin is 714 pounds.

1.1.3 TRAJECTORY

The trajectory for Mission 1 consists of a launch from Cape Kennedy Launch Complex 37B, on an azimuth of 44 degrees to an initial orbit at an altitude of 80-n. mi. and an inclination of 50 degrees. The insertion characteristics are as follows:

Latitude:	39.37 degrees north
Longitude:	65.93 degrees west
Relative Azimuth:	53.4 degrees
Velocity:	25,665 feet per second
Mission Time:	T+595.54 seconds

The parking orbit duration is 3 hours, 10 minutes. In the second earth orbit a coplanar Hohmann transfer maneuver, using the SPS, will place the spacecraft in the 200-n. mi. mission orbit. The transfer orbit duration is 45 minutes.

Experiment constraints on the mission trajectory are as follows:

Seasonal:	midwinter/midsummer
Illumination:	no constraint
Vehicle orientation:	earth pointing
Stabilization:	$\pm$ 5 degrees for 5 days, $\pm$ 0.2 degrees for remaining days.

A ground trace of Mission 1 is shown in Figure 1-3.

1.1.4 OPERATIONS

After parking orbit insertion, subsystem checks and orbital landmark navigation sightings are conducted, and the orbit ephemeris is established and verified by the Manned Space Flight Network (MSFN).

Transposition and docking is accomplished, and the S-IVB stage (including the instrument unit and the spacecraft LEM adapter) is separated. During the second parking orbit, the SPS is used to insert the spacecraft into a transfer orbit.

Subsystem checks and the establishment of a new orbital ephemeris follow SPS cutoff. The spacecraft coasts in the transfer orbit until apogee, at which time the SPS is fired a second time to circularize the spacecraft orbit at the nominal 200-n. mi. mission altitude.

The crew again performs subsystems checks and establishes and verifies an ephemeris for the 200-n. mi.orbit. The interlock and LEM cabin are pressurized, the LEM is manned and checked, and the mission experiments are initiated.

At 4.1 hours after liftoff the astronauts begin a work/rest cycle. They conduct experiments, adjust and calibrate associated apparatus, perform their station-keeping duties, and assume their normal spacecraft responsibilities throughout the nominal 14-day mission.

1.1.5 CREW ACTIVITIES

Flight operational duties include display and control monitoring; performing IMU alignments and systems status checks; and providing attitude control for orbit insertion, course corrections, and transposition maneuvers. During each day in the mission orbit, the crew is primarily concerned with experiments, communication with MSFN, and flight operations. Personal functions are performed in the time remaining.

The typical crew member day consists of 10 hours on duty and 14 off (6 hours sleep, 5 hours rest, and 3 hours for eating and personal hygiene). Approximately 4.75 man hours per day are required for status checks of CSM and LEM systems, and for activities such as fuel-cell purging, battery charging, and lithium hydroxide canister replacement. IMU alignments are performed eight times per day during this mission.

Crew experiment activities include the following:

a. For multispectral target characteristics and synoptic earth mapping, two or more members of the crew set up the experiment and load the cameras. The experiment activities involve evaluations of atmospheric conditions

and illumination, operating and monitoring of the cameras, and the use of the view finders for ground observation. The experiment is repeated every third day.

b. For radiation monitoring, the astronauts observe the spectrometer outputs and dosimeter records.

c. The biomedical series of experiments involve activities, such as obtaining blood and urine samples and evaluating the otolith mechanism and the semicircular canals.

d. The artificial gravity experiment involves extravehicular activity to attach cables from the CSM to the LEM. The two modules are then separated and rotation is initiated. The effects of the rotation are monitored as the rotational rates and g-levels are changed. At the conclusion of the test the rotation of the modules is terminated and the equipment is stowed. Additional EVA is necessary to stow the equipment.

e. The behavioral experiments consist of evaluations of sensory and perceptual processes, psycho-motor functions, and balance, using a series of test apparatus stowed in a console.

The percent of time spent at various functions by the astronauts during the mission is as follows:

Function	Time Utilization (Percent)
Experiments	31.0
Flight Operations	13.7
Personal	54.3
Unscheduled	1.0
	100.0

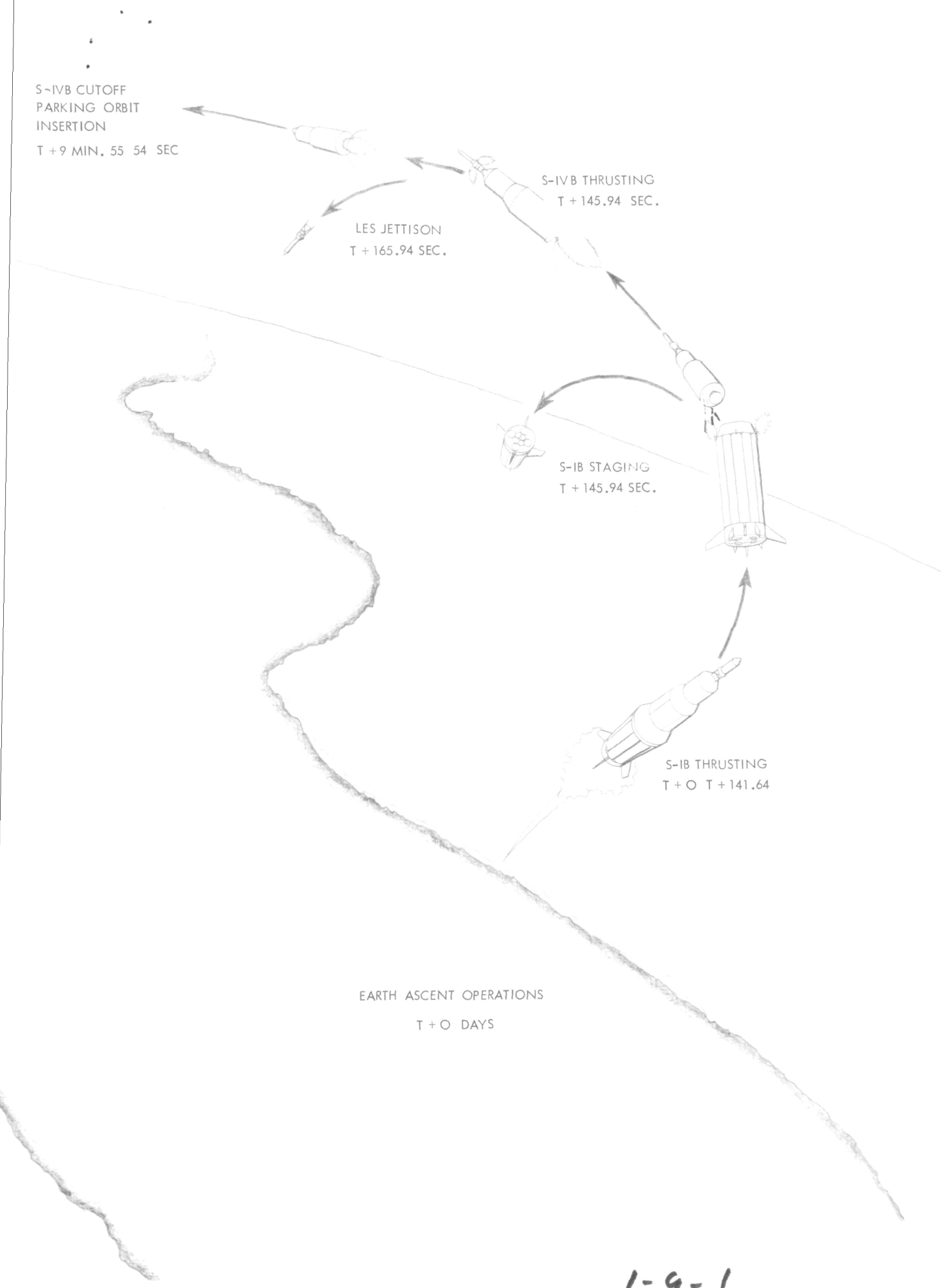
Deviations from source-recommended experiment scheduling were required because of excessive experiment time requirements. The proposed and scheduled experiment times were:

Source-Recommended Experiment Time	572 man-hours
Scheduled Experiment Time	310.7 man-hours

1.1.6 DATA FLOW

The data flow requirements for Mission 1 include up to nine analog and two digital PCM channels at one time for transmission. More than 8000 minutes of data will be

recorded during Mission 1, and the total transmission time available for data dumping is less than 4000 minutes. Film and magnetic tape requirements will exceed the assumed maximum recoverable data-payload weight of 250 pounds.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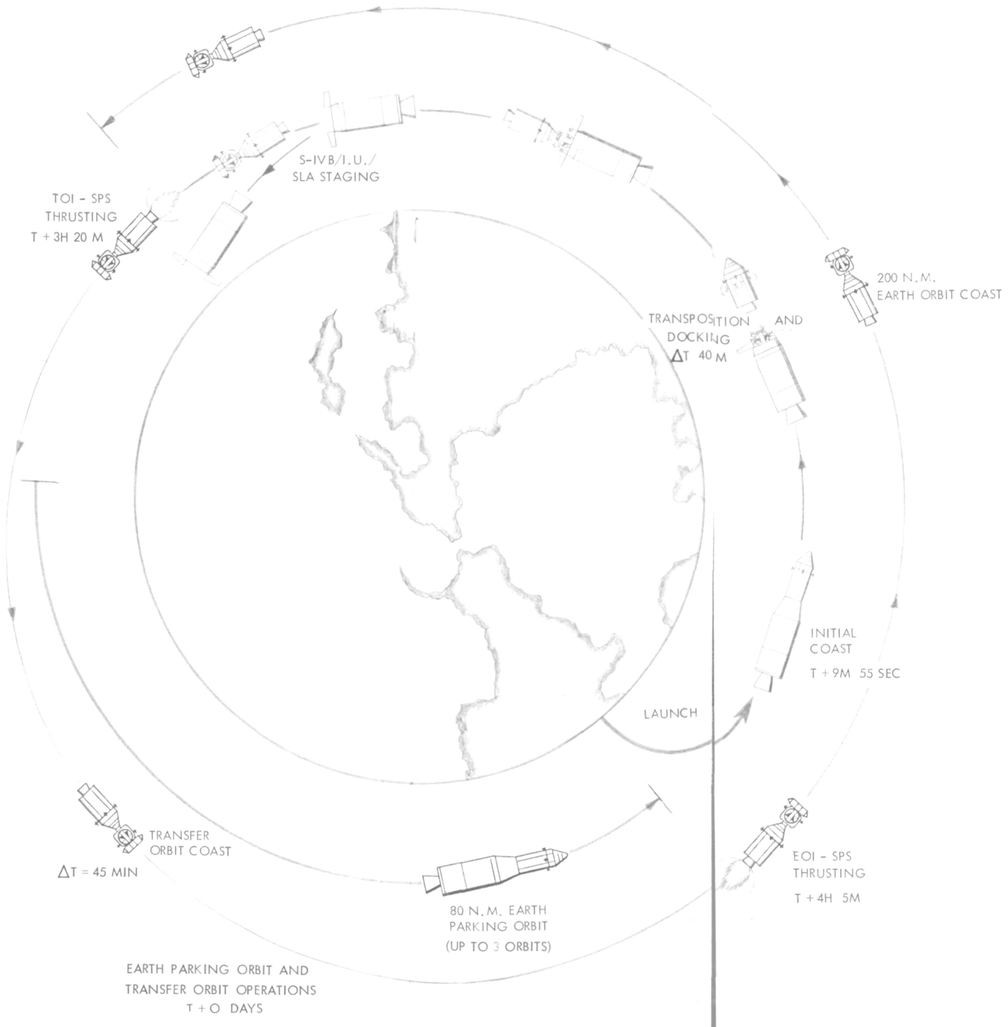
INSERTION
T + 9 MIN. 55 54 SEC
S-IVB THRUSTING
T + 145.94 SEC.
LES JETTISON
T + 165.94 SEC.
S-IB STAGING
T + 145.94 SEC.
S-IB THRUSTING
T + O T + 141.64
EARTH ASCENT OPERATIONS
T + O DAYS

MISSION 1 INTERMEDIATE INCLINATION SURVEY



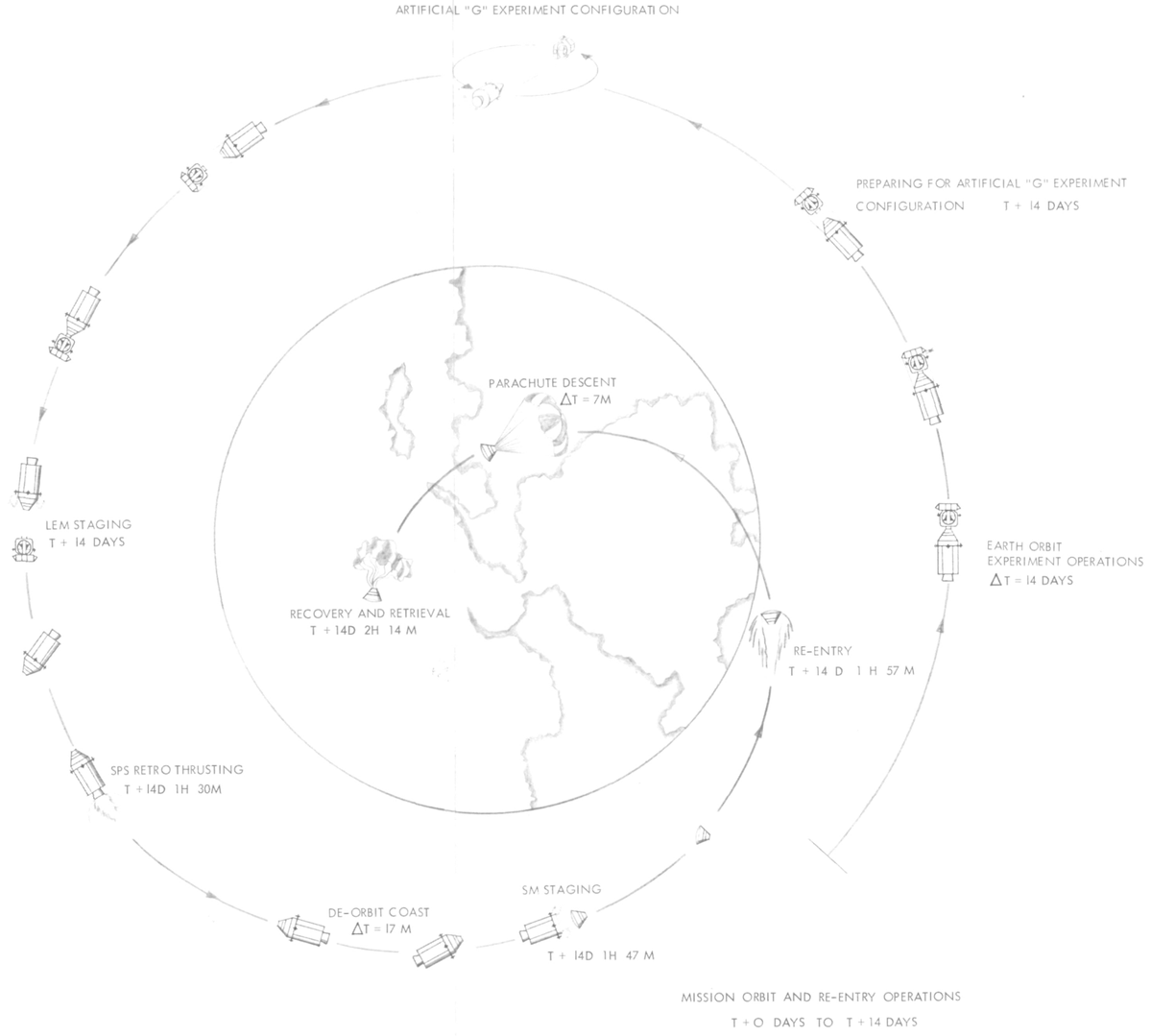
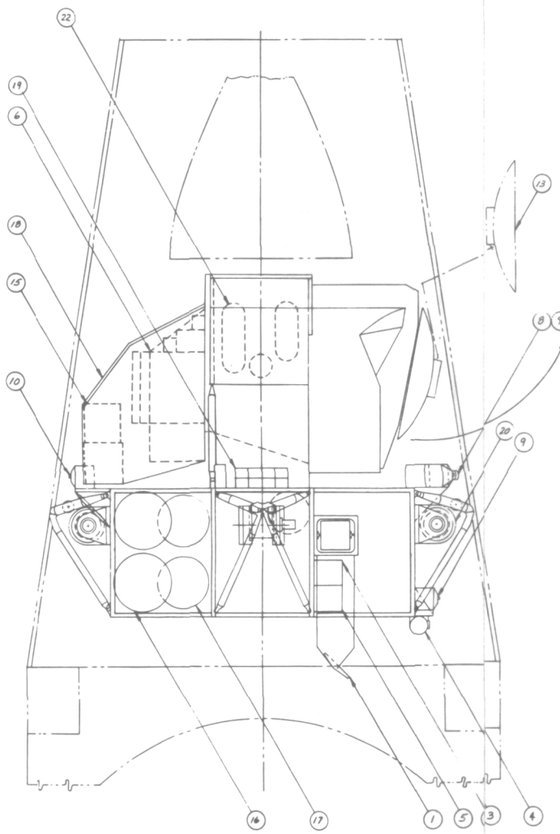


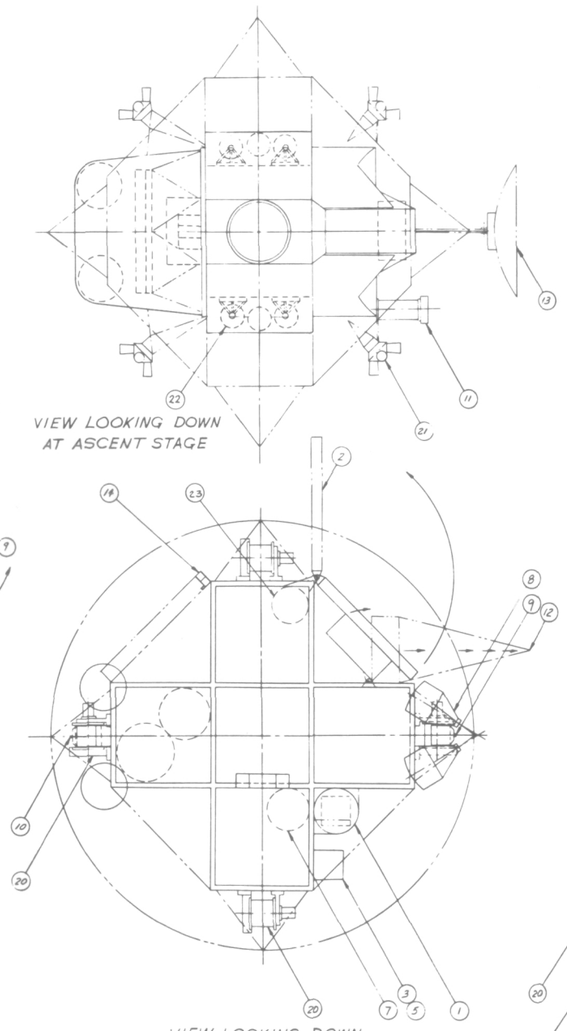
Figure 1-1. Configuration History for the Intermediate Inclination Survey

KEY

No.	Experiment	Name
1	0901	16-in. Telescope
2	0901	Microwave Imager Antenna
3	0901	Grating Spectrometer
4	0901	Spectro Photometer
5	0901	Multi Spectral Camera
6	0902,0901	Electronics Bay
7	0901	Cryogenics Storage
8	0902	24-in. FL Camera
9	0902	6-in. FL Camera
10	0902	70mm Star Camera
11	0902	Image Viewfinder
12	0902	VHF Pulse Radar Antenna
13	0902	Microwave Radiometer Antenna
14	0501	Radiation Environment Spectrometers
15		Fuel Cells (2)
16		H_2 Tanks (2)
17		O_2 Tanks (2)
18		Radiators
19		LioH Storage
20	0301	Artificial "g" Winch (4)
21	0301	RCS
22	0301	RCS Fuel Tanks
23		GOX Tank

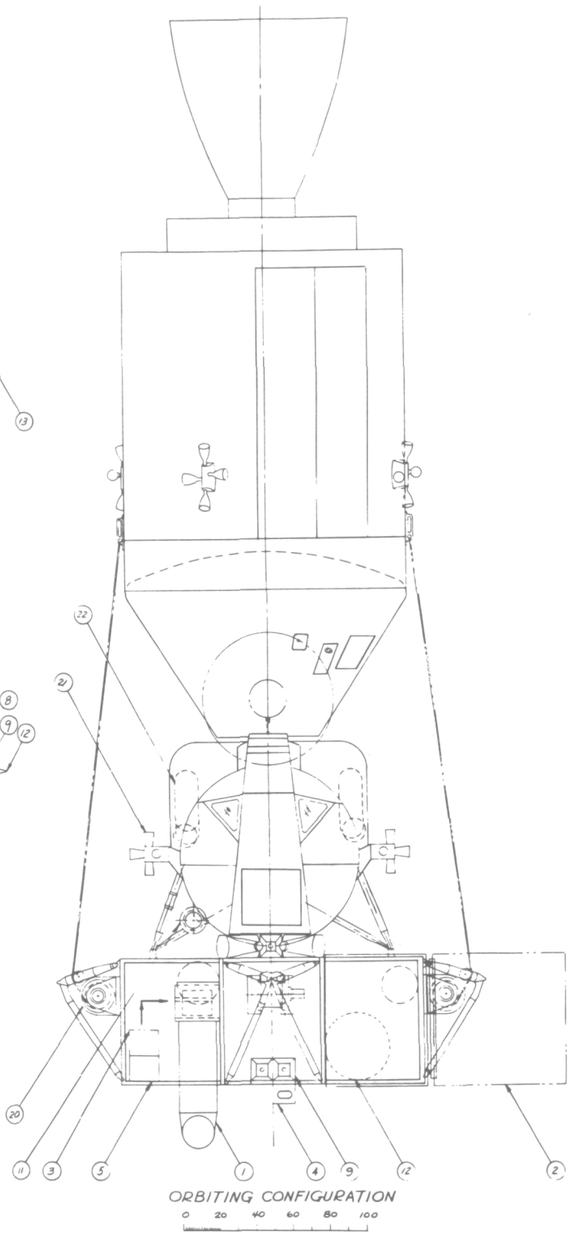


LAUNCH CONFIGURATION



VIEW LOOKING DOWN AT ASCENT STAGE

VIEW LOOKING DOWN AT DESCENT STAGE



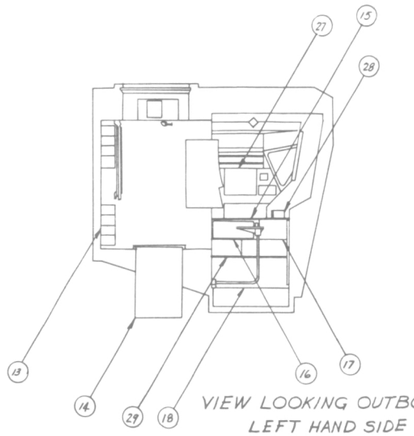
ORBITING CONFIGURATION

0 20 40 60 80 100

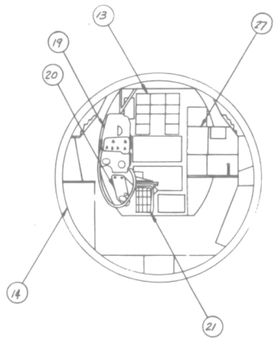
Figure 1-2. Mission 1 Spacecraft Configuration and Experiment Location (31, Page 1-5.18) (Sheet 1 of 2)

KEY

No.	Experiment	Name
1	0901	16-in. Telescope
2	0901	Spectro Photometer
3	0902,0901	Electronics Bay
4	0902	24-in. FL Camera
5	0902	6-in. FL Camera
6	0902	70mm Star Camera
7	0902	Image Viewfinder
8	0902	Microwave Radiometer Ant.
9		Fuel Cells (2)
10		H_2 Tanks (2)
11		O_2 Tanks (2)
12		Radiators
13		LioH Storage
14	0100	Biomed
15	0501	Pulse Height Analyser
16		Recorders
17		Digital Computer
18		Film & Tape Storage & Log Book
19		ECS
20		Water Module
21		Fan
22	0501	Battery Charger
23	0100-0200	Basic Lab
24		Main Panel Floodlights
25		Food Storage
26	0301	Artificial "g" Winch
27	0200	Integrated Human Performance Test Console
28	0501	Rate Meter & Ionization Chamber
29	0301	"g" sensor & Rotation Rate Sensor



VIEW LOOKING OUTBOARD
LEFT HAND SIDE



VIEW LOOKING AFT

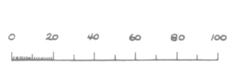
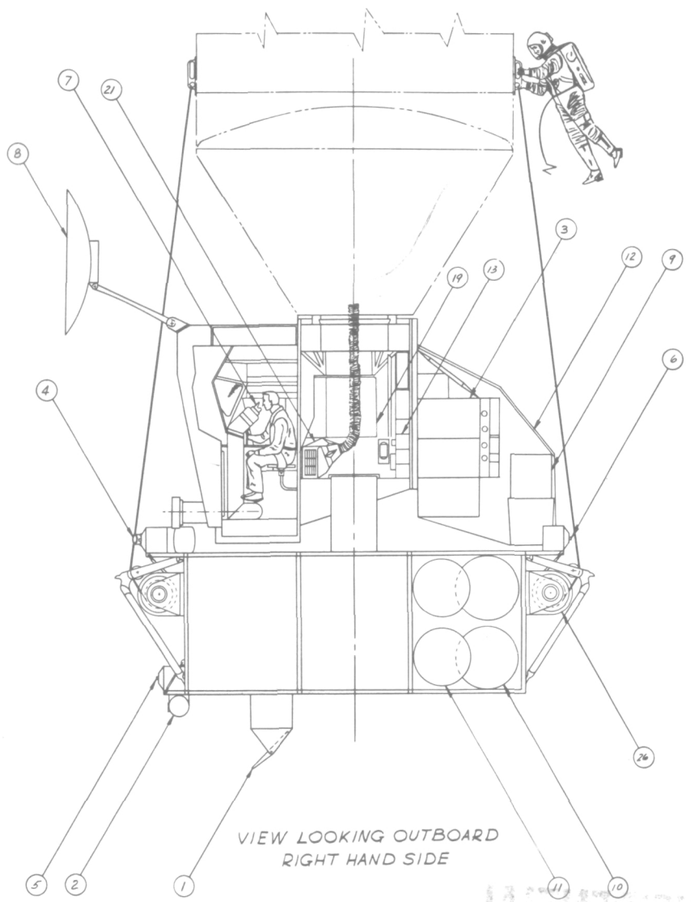


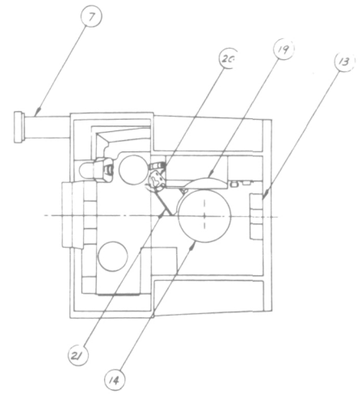
Figure 1-2. Mission 1 Spacecraft Configuration and Experiment Location (31, Page 1-5.19) (Sheet 2 of 2)

CONFIDENTIAL

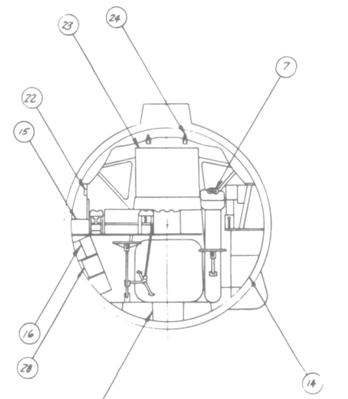
CONFIDENTIAL



VIEW LOOKING OUTBOARD
RIGHT HAND SIDE



PLAN VIEW



VIEW LOOKING FORWARD

1-12-2

CONFIDENTIAL

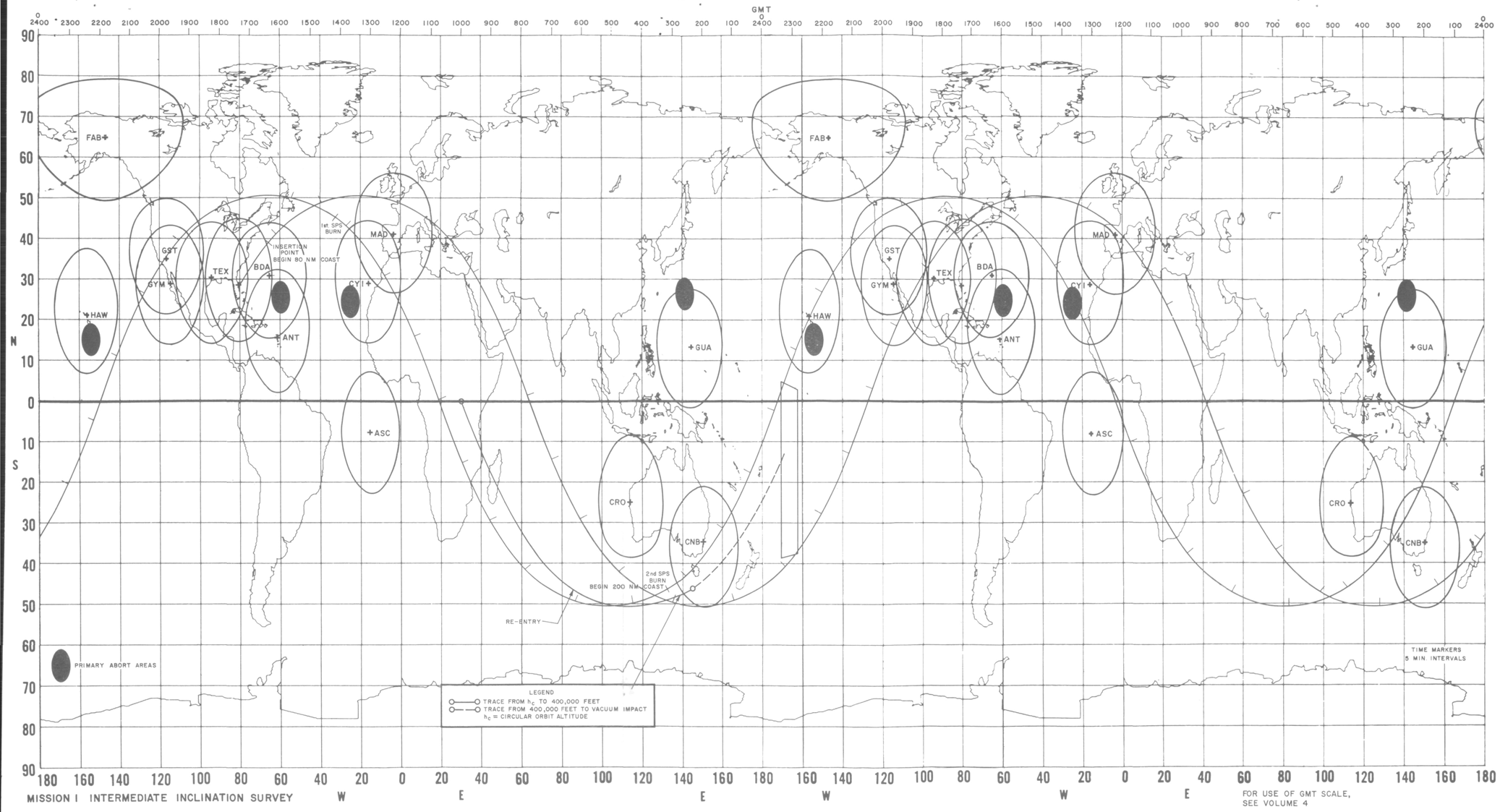


Figure 1-3. Mission 1 - Launch, Mission Orbit Insertion and Re-Entry Ground Trace

1-13-1

1-13-2

1.2 MISSION 2 - SATURN IB TO SATURN IB RENDEZVOUS

The primary objective of Mission 2, Saturn IB to Saturn IB Rendezvous, is to obtain the initial data necessary to establish a space laboratory for astronomical observation and experiments in the physical sciences. The total mission duration is 90 days.

A first spacecraft, "A," consisting of an Apollo Block II CSM and a LEM/LAB will be placed in a nominal 200-n. mi. circular earth orbit at an inclination of 29.5 degrees. The spacecraft will carry a crew of three, and mission expendables and subsystems to permit operations for 45 days in earth orbit.

Thirty-five to 45 days after launch of Spacecraft A, a second spacecraft, "B," will be placed in a similar orbit. The two spacecrafts will rendezvous, and predesignated personnel and materiel will transfer. Spacecraft A will separate from the LEM-A/Spacecraft B configuration, de-orbit, and return to earth for recovery. Spacecraft B will remain in orbit for 45 additional days.

1.2.1 EXPERIMENTS

1.2.1.1 Spacecraft A

Sixteen types of experiments in the bioscience-physical science fields are planned for the first flight of Mission 2. The experiments include the study of living organisms in a zero-g environment, development of EVA operations techniques, and hardware developments for extended study of these and other subjects. A substantial portion of the experiments is in evaluations of spacesuit assemblies.

The experiments to be conducted are as follows:

Experiment Number	Category
0100	Biomedical
0200	Behavioral
0501	Radiation Environment Monitoring
0601	Capillarity Studies
0602A	Kinetics and Dynamics of Vapor/Gas Bubbles
0602B	Liquid Drop Dynamic Studies

Experiment Number	Category
0603A	Pool Boiling in Long-Term Zero-g
0603B	Nucleate Condensation of Fluids in Zero-g
0604	Density Gradient of a Fluid
0605	Crystallization Studies
0606	Cosmic Ray Emission
1501	Evaluation of Advanced Spacesuit Assemblies
1502	Development of Manned Locomotion and Maneuvering Capability
1503	Emergency Techniques for Rescue
1504	Development of Personnel and Cargo Transfer Operations
1505	Maintenance and Repair

1.2.1.2 Spacecraft B

The experiments for the second flight include rendezvous studies; continuation of the living organism studies; physical science and space environment studies; further investigation of extravehicular operations, including cargo and personnel transfer, rescue operations, and spacesuit evaluations; and the effects of space flight on biological systems (microbes and mammals). An onboard centrifuge is included among the experiment equipment. In addition to the experiments began on Flight A, the experiments for Flight B include the following:

Experiment Number	Category
0302	Onboard Centrifuge
0401	Microbial Genetics and Growth
0402	Development Biology
0403	Mammalian Physiology
0404	Limb Regeneration and Wound Healing
0405	The Effects of Drugs on Mammalian Behavior
0406	Soft Capture, Enumeration, and Identification of Spaceborne Microorganisms

1.2.2 CONFIGURATION

The configuration history for Mission 2 is shown in Figure 1-4; the location of equipment for experiments is shown in Figures 1-5 and 1-6.

The total weight of experiment equipment for the first flight is 2650 pounds, of which more than half is required for an evaluation of spacesuit assemblies. The equipment volume is 156.5 cubic feet. The Spacecraft A experiments require an average power of 245 watts, with peaks to 1350 watts.

Spacecraft B experiment equipment weighs approximately 2250 pounds and has a volume of 486.9 cubic feet. Approximately 43 percent of the experiment weight is attributed to the onboard centrifuge. An average power of 352 watts and peaks to 1500 watts is required for experiments.

The available payload margin for Spacecraft A, defined as the difference between the total payload weight and the maximum allowable weight, is 2030 pounds. The margin for Spacecraft B is 1413 pounds.

1.2.3 TRAJECTORY

1.2.3.1 Vehicle A

The first space vehicle is launched from Cape Kennedy Launch Complex 34 by means of both stages of the Saturn IB, at an azimuth of 83 degrees, into an 80-n. mi parking orbit, inclined 29.5 degrees to the equatorial plane. The insertion characteristics are as follows:

Latitude	28.11 degrees North
Longitude	62.61 degrees West
Relative Azimuth	100.2 degrees
Velocity	26,665 feet per second
Mission Time	T +595 seconds

Using the SPS, nominally at T +3 hours (during the second orbit), a Hohmann transfer will place the spacecraft into the 200-n. mi. mission orbit. After 45 minutes in the transfer trajectory, the SPS is reignited for mission orbit insertion.

During the flight, three orbit-restoration SPS firings, spaced 15 days apart, will be used to maintain the 200-n. mi. altitude.

Experiment constraints on the trajectory are as follows:

Seasonal	None
Illumination	None
Vehicle Orientation	Earth Pointing
Stabilization	±5 degrees (normal), (±0.5 degrees for 19 hours)
Ephemeris Accuracy	None specified

1.2.3.2 Vehicle B

The second space vehicle is launched from Cape Kennedy launch complex 37B on a launch azimuth dictated by rendezvous requirements. The Saturn IB launch vehicle delivers the spacecraft into a circular, 80-n. mi. orbit. Orbital insertion requirements are similar to those of Vehicle A. Experiment constraints are also similar except for the following:

Vehicle Orientation	Variable
Stabilization	±5 degrees

Spacecraft B is the active spacecraft in the rendezvous maneuver. It is provided with propulsion for a 0.32-degree plane change capability that allows a rendezvous launch window of 24 minutes. Five such launch opportunities occur within a ten-day period; two of them on consecutive days. Two hours of phasing time in the 80-n. mi. orbit is alloted to Vehicle B.

Ground traces for Mission 2 are shown in Figures 1-7 and 1-8.

1.2.4 OPERATIONS

Transposition and docking for Spacecraft A occurs during the initial 80-n. mi. orbit and is immediately followed by jettison of the S-IVB stage. The SPS is used for insertion into the transfer orbit and for circularization at the 200-n. mi. mission altitude.

After the interlock and LEM are pressurized and manned, and required subsystems checks are completed, the astronauts begin a work/rest cycle. They conduct scheduled

experiments and assume their normal spacecraft responsibilities until the forty-fourth day of the mission, at which time preparations begin for rendezvous with Spacecraft B.

Spacecraft B accomplishes transposition during the 80-n. mi. parking orbit, and the S-IVB is staged. At the correct phasing point, Spacecraft B uses the SPS for insertion into a transfer orbit with an apogee of 200-n. mi. Spacecrafts A and B track each other during the Spacecraft B ascent coast. Rendezvous maneuvers are accomplished by Spacecraft B and the two spacecrafts assume a LEM-to-LEM docked configuration. When the planned crew and materiel transfers are completed, CSM A separates from the remaining configuration, deorbits, re-enters, and is recovered. CSM B/LEM A and LEM B continue the 200-n. mi. mission orbit for the following 45 days.

1.2.5 CREW ACTIVITIES

Duties of the crews of Flights A and B, from launch to insertion into the 200-n. mi. mission orbit and from deorbit to touchdown, consist of monitoring displays and controls, performing IMU alignments and systems status checks, controlling the spacecraft attitude for orbit insertion, course correction, and transposition and docking maneuvers, and communicating with MSFN. These same tasks are performed as necessary during the mission orbit phases; however, the crew also assumes responsibility for the experiments. Personal functions are performed in the time remaining.

Systems status checks for the CSM and LEM in mission orbit average 4.75 man-hours per day, which also includes such activities as fuel-cell purging, battery charging, and lithium hydroxide cannister replacement.

The typical work/rest cycle consists of approximately 10 hours on duty and 14 hours off (6 hours sleep, 5 hours rest, and 3 hours eating and personal hygiene).

Crew experiment activities for Flight A of Mission 2 include:

a. Selected biomedical experiments.
b. Behavioral experiments.
c. Radiation monitoring.
d. One astronaut, using specialized equipment, investigates the physical behavior of selected material samples. These include capillarity action, gas/vapor equilibrium, fluid density gradients and crystallization studies.
e. Cosmic ray intensity is investigated, requiring EVA placing and retrieving a sensitized film pack.

f. All three astronauts participate in evaluations of spacesuit assemblies, both within the CSM and in EVA, plus development of manned locomotion and maneuvering capabilities, personnel and cargo transfer operations, emergency rescue techniques, and in-space maintenance and repair activities. The experiments require extensive EVA for perfecting operational techniques.

Spacecraft B experiment activities include rendezvous maneuvers with Spacecraft A and a series of biological experiments, as follows:

a. The astronauts are centrifuged daily in an onboard centrifuge to determine the effects of exposure to accelerations as a means of deterring possible long-term effects of the zero-g environment.
b. Microbial genetics and growths under zero-g conditions are investigated by propagation of microbe colonies in an onboard incubator using standard bacteriological procedures. Unicellular and tissue organisms are similarly investigated.
c. Mammalian physiology is studied utilizing a monkey in a controlled zero-g environment. The crewmen take daily observations, adjust recording equipment and the primate's life support system, and perform preliminary data reduction on the effects of immobilization, isolation, and sensory deprivation.
d. Newts and planaria are continuously observed to evaluate limb regeneration and wound healing in these species under zero-g conditions.
e. The effects of drugs on mammalian behavior are investigated using rat colonies, which are observed after the administration of various drugs.
f. Enumeration of spaceborne microorganisms requires EVA to expose sample cultures to space for subsequent recovery, incubation, and storage.

The percent of time spent by the astronauts at various functions during the first 14 days in the Flight A mission orbit is as follows:

Function	Time Utilization (Percent)
Experimentation	24.1
Flight Operations	10.1
Personal	58.6
Unscheduled	7.2
	100.0

Deviations from source-recommended experiment scheduling were required because of excessive experiment time requirements. The proposed experiment times for Flight A for a 45-day mission, and the projected experiment time scheduled for 45 days based on the 14-day sample were:

Source-recommended Experiment Time	1808	man-hours
Scheduled Experiment Time	776.8	man-hours

NOTE

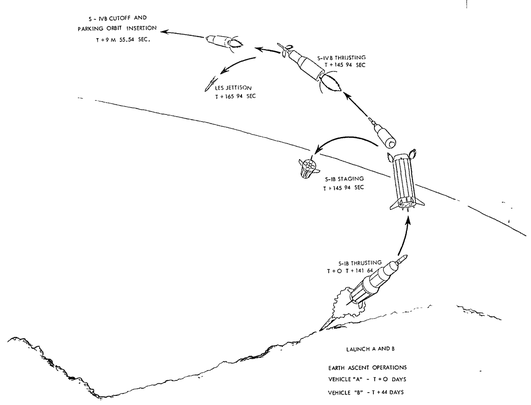
Since Flight B crew activities were scheduled for only the first three days of the mission, experiment times were not projected for the 45-day mission.

1.2.6 DATA FLOW

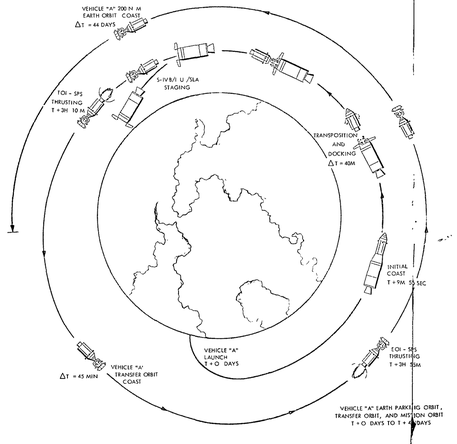
The data flow requirements for Mission 2 include a minimum of 6118 minutes of transmission time during the mission, and up to six analog and one digital PCM channels for transmission at the same time. Recording activity, however, is well within the presently planned spacecraft data transmission capabilities.

A noncoverage interval greater than 120 minutes will occur on the average of once every three days with the presently planned network of 14 S-band telemetry ground stations.

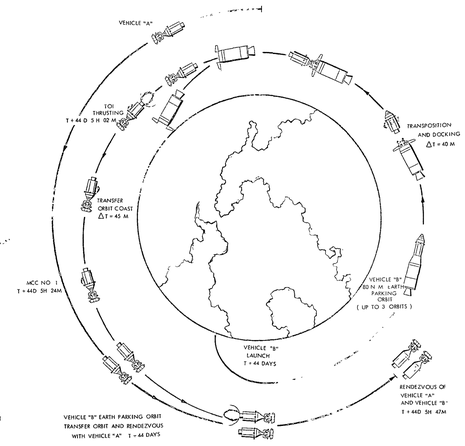
MISSION 2 SA-1B TO SA-1B RENDEZVOUS



1-23-1



1-23-2



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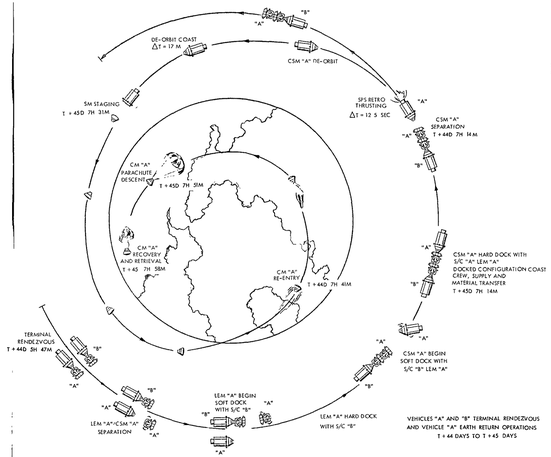

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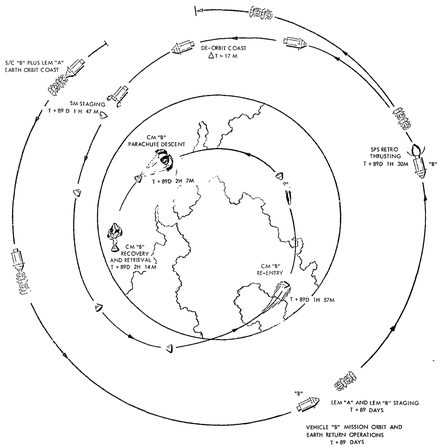
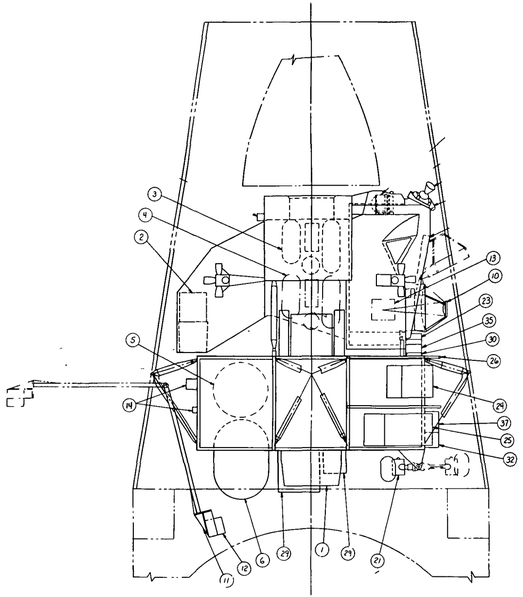


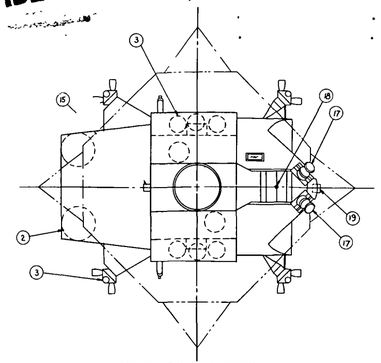
Figure 1-4. Mission 2 Configuration History

KEY

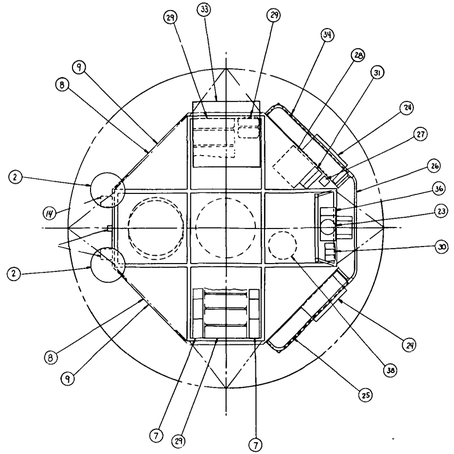
No.	Experiment	Name
1		Docking Ring
2		FCA
3		RCS
4		Supplementary RCS (Flt 7 D only)
5		O_2
6		H_2
7		LiOH
8		Equipt Radiator
9		FCA Radiator
10	605	Solar Concentrator
11	606	Boom for Cosmic Ray Emulsion Exper
12	606	Magnetometer
13	605	Crystallization Studies Test Chamber during exper
14	0501	Radiation Monitor Equipt - Electron Spectrometer (2) Proton Alpha Spectrometer (1)
21	1501,2,3,4,5	Cameras (TV & Movie)
22	1501	ECS Station
23	1501	Safety Line
24	1501	AMU
25		Hard Space Suit
26		Rail & Platform
27		AMU Resupply Station
28	1501	AMU Fuel Supply
29	1502	Cargo Net
30	1502	Tethers (3)
31	1502	AMU Spare Batteries
32	1503	Personnel Transfer Equipt
33	1503	Logistics Shapes Storage
34	1503	Tools for Rescue & Pickup of Objects
35	1504	Motor Reel
36	1504	Rope Gun
37	1505	EVA Tool Kit
38		GOX



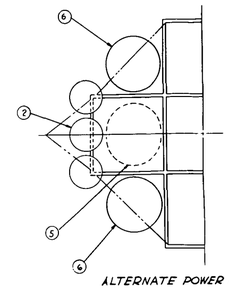
LAUNCH CONFIGURATION



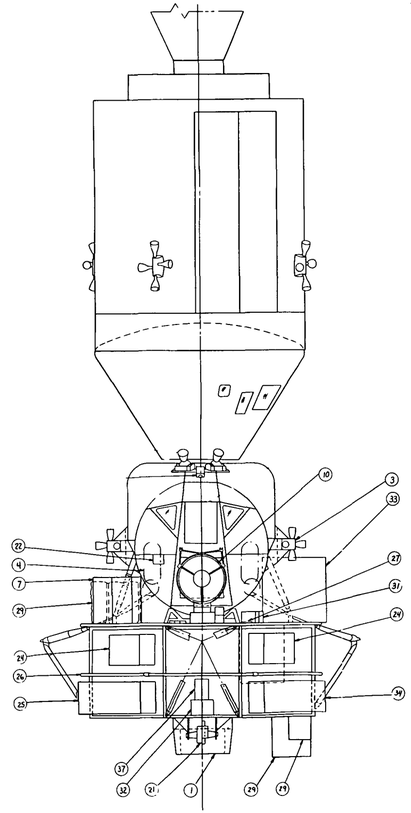
VIEW LOOKING DOWN AT ASCENT STAGE



VIEW LOOKING DOWN AT DESCENT STAGE



ALTERNATE POWER PACK CONFIGURATION

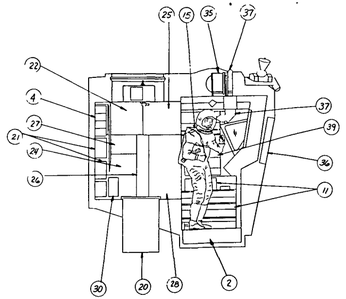


ORBITING CONFIGURATION

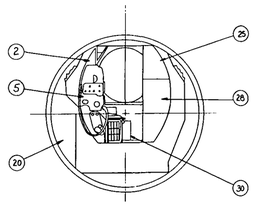
Figure 1-5. Spacecraft Experiment Configuration, Mission 2, Launch A (Sheet 1 of 2) (32 pages 1-7.29)

KEY

No.	Experiment	Name
1		Air Duct
2		Food
3		GOX Tank
4		LioH
5		ECS
6		O_2
7		FCA
8		H_2
9		Attitude Controller Assy
10		Translation Controller Assy
11		Recorders
12		S & C, Power, N&G, ECS, RCS, Comm Panel
13		RCS
14		Docking Ring
15	501	Radiation Environment Monitor Panel
16	501	Radiation Environment Monitor Equipt
17	0100 & 0200	Biomed Incubator
18	0100 & 0200	Biomed Refrigerator
19	0100 & 0200	Biomed Panel
20	0100 & 0200	Biomed Storage
21		CDU, LGC, PSA & Signal Conditioner
22	0601	Capillarity Studies Exper.
23	0602A	Kinetics & Dynamics of Vapor /Gas Exper.
24	0602B	Liquid Drop Dynamics Study Exper.
25	0603A	Pool Boiling in Long Term zero-g Environment Exper.
26	0603B	Nucleate Condensation of Fluids in zero- Exper.
27	604	Density Gradient of a Fluid at near-critical state Exper.
28	605	Crystallization Studies Exper. (Stowed)
29	605	Solar Concentrator
30	606	Cosmic Ray Emulsion Exper. (Stowed)
31	606	Cosmic Ray Emulsion Exper. (Exposed)
32	606	Magnetometer

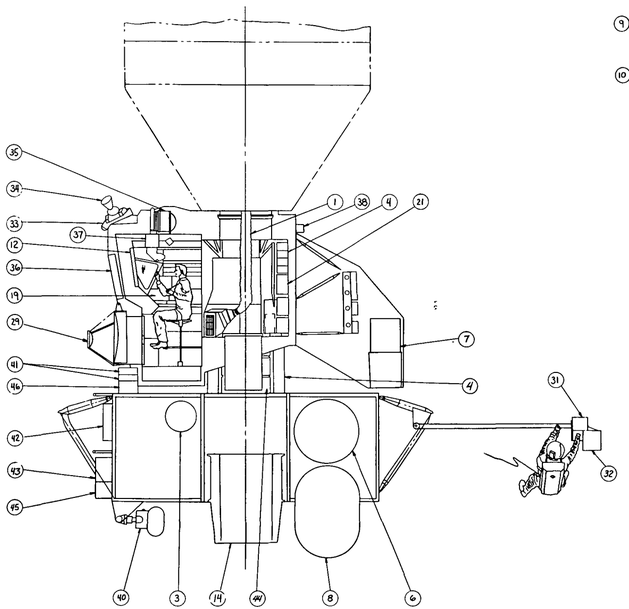


VIEW LOOKING OUTBOARD
LEFT HAND SIDE



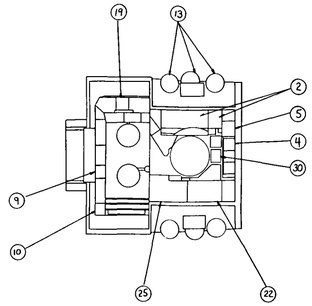
VIEW LOOKING AFT

35	on	IMU & Electronics
36	Flt.	Doppler, Altimeter
37	219	Telescope
38	1407	Sun Sensor
39	1500	Extravehicular Operations Panel
40	1500	Camera
41	1501,2,3, 4,5	Safety Lines
42	1501,2,3, 4,5	AMU
43	1505	EVA Tool Kit
44	1502	Cargo Net
45	1503	Personnel Transfer
46	1504	Motor Reel

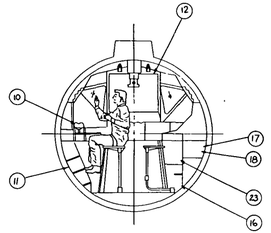


VIEW LOOKING OUTBOARD
RIGHT HAND SIDE

0 20 40 60 80 100



PLAN VIEW



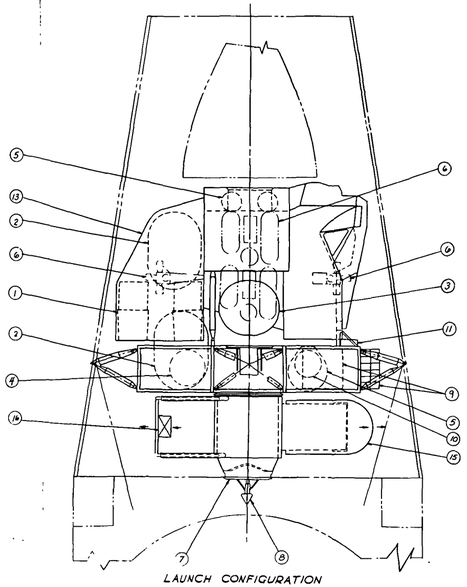
VIEW LOOKING FORWARD

Figure 1-5. Spacecraft Experiment Configuration, Mission 2 Launch A (Sheet 2 of 2) (32 pages 1-7.29)

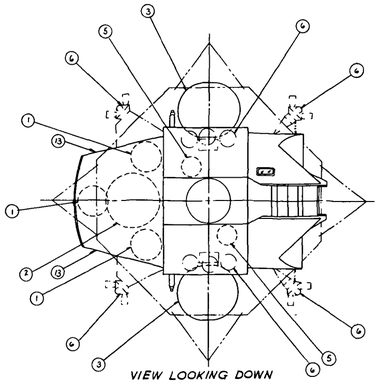
CONFIDENTIAL

KEY

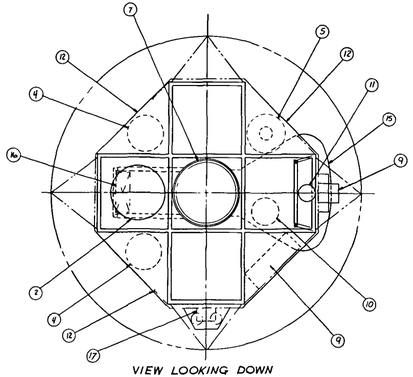
No.	Experiment	Name
1		Fuel Cell Assy
2		H_2 (Block III)
3		O_2 (Block III)
4		O_2 (Block II)
5		Water Tanks
6		RCS (on S/C 'D' Only)
7		Tunnel & Docking Ring
8		Docking Probe
9		LiOH
10		GOX
11		Safety Line
12		Equipment Radiator
13		Fuel Cell Radiator
14		Flight 7
15	0302	On-Board Centrifuge
16	0302	Centrifuge Counterweight
17	0406	Spaceborne Micro-organism Cartridges (Stowed)
18	0406	Spaceborne Micro-organism Cartridges (Exposed)



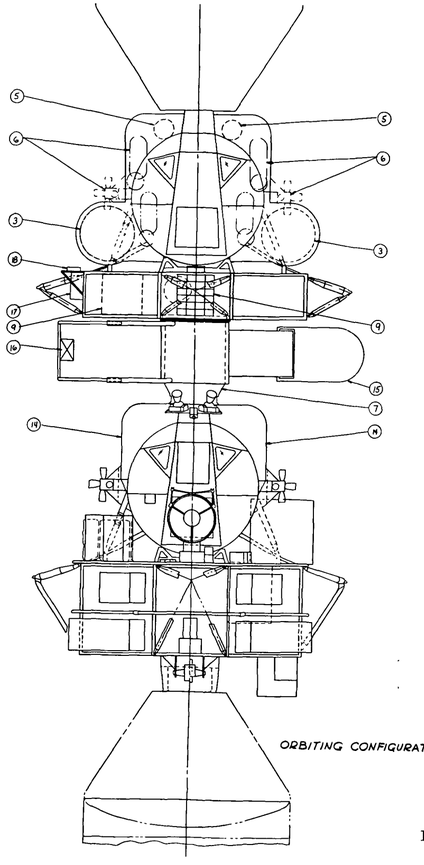
LAUNCH CONFIGURATION



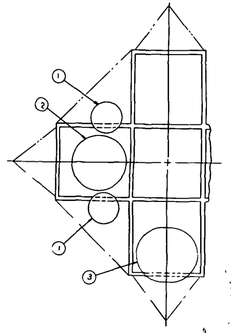
VIEW LOOKING DOWN AT ASCENT STAGE



VIEW LOOKING DOWN AT DESCENT STAGE



ORBITING CONFIGURATION



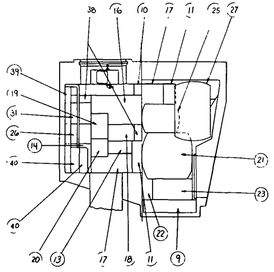
ALTERNATE POWER PACK CONFIGURATION

Figure 1-6. Spacecraft Experiment Configuration, Mission 2, Launch B (Sheet 1 of 2) (32 pages 1-8, 31)

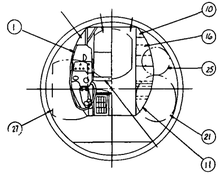
KEY

No.	Experiment	Name
1		ECS
2		Tunnel & Docking Ring
3		Film Storage
4		GOX
5		Fuel Cell Assy
6		H_2
7		LioH
8		Flight 7 Lab
9	401,2,3,4,5	Freezer
10	401	Lyophilization
11	401,403,404	Chemical & Equipment Storage
12	401,402,406	Incubators
13	401,402,406	Microscope
14	401,402	Refrigerator (-15°c)
15	402	Refrigerator (-20°c)
16	402	Culture Flasks
17	402,403,404	Supply Cabinets (Includes 35mm Camera)
18	402	Scintillation Counter
19	402	Particle Counter
20	402	Centrifuge
21	403	Chimpanzee Container (Pressurized)
22	403	Waste Management (Chimpanzee)
23	403	Food Management System
24	403	Instrumentation for Chimpanzee Panel
25	404	Planaria & Newts Chamber (Pressurized)
26	404	Refrigerator (-5°c)
27	405	Rats Cages (Pressurized)
28	405	Food Storage
29	405	Waste Storage
30	405	Quick Freezer
31	406	Refrigerator (+5°c)
32	302	On-Board Centrifuge
33	302	Centrifuge Counterweight

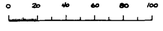
Figure 1-6. Spacecraft Experiment Configuration, Mission 2, Launch B (Sheet 2 of 2) (32 pages 1-8.31)

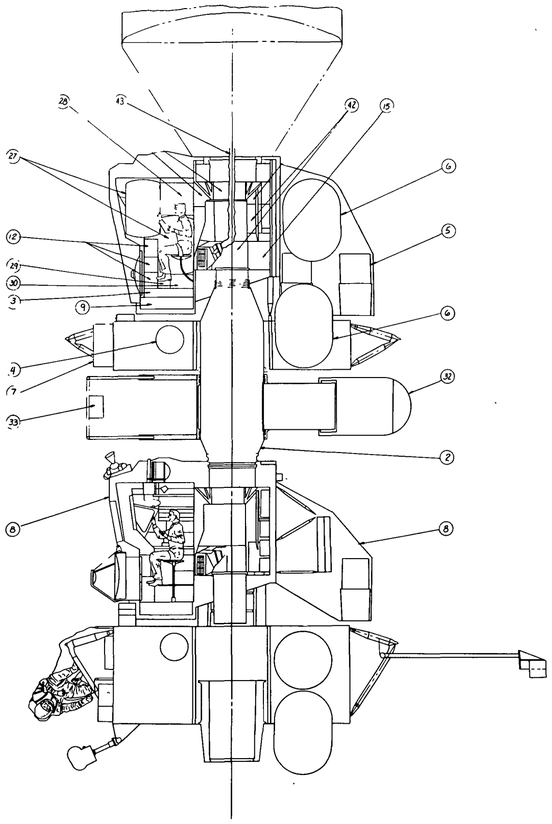


VIEW LOOKING OUTBOARD LEFT HAND SIDE

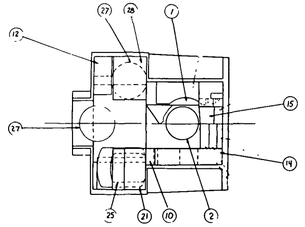


VIEW LOOKING AFT

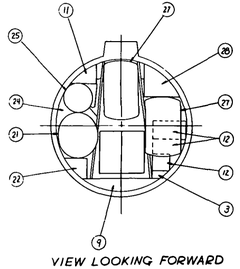




VIEW LOOKING OUTBOARD RIGHT HAND SIDE



PLAN VIEW



VIEW LOOKING FORWARD

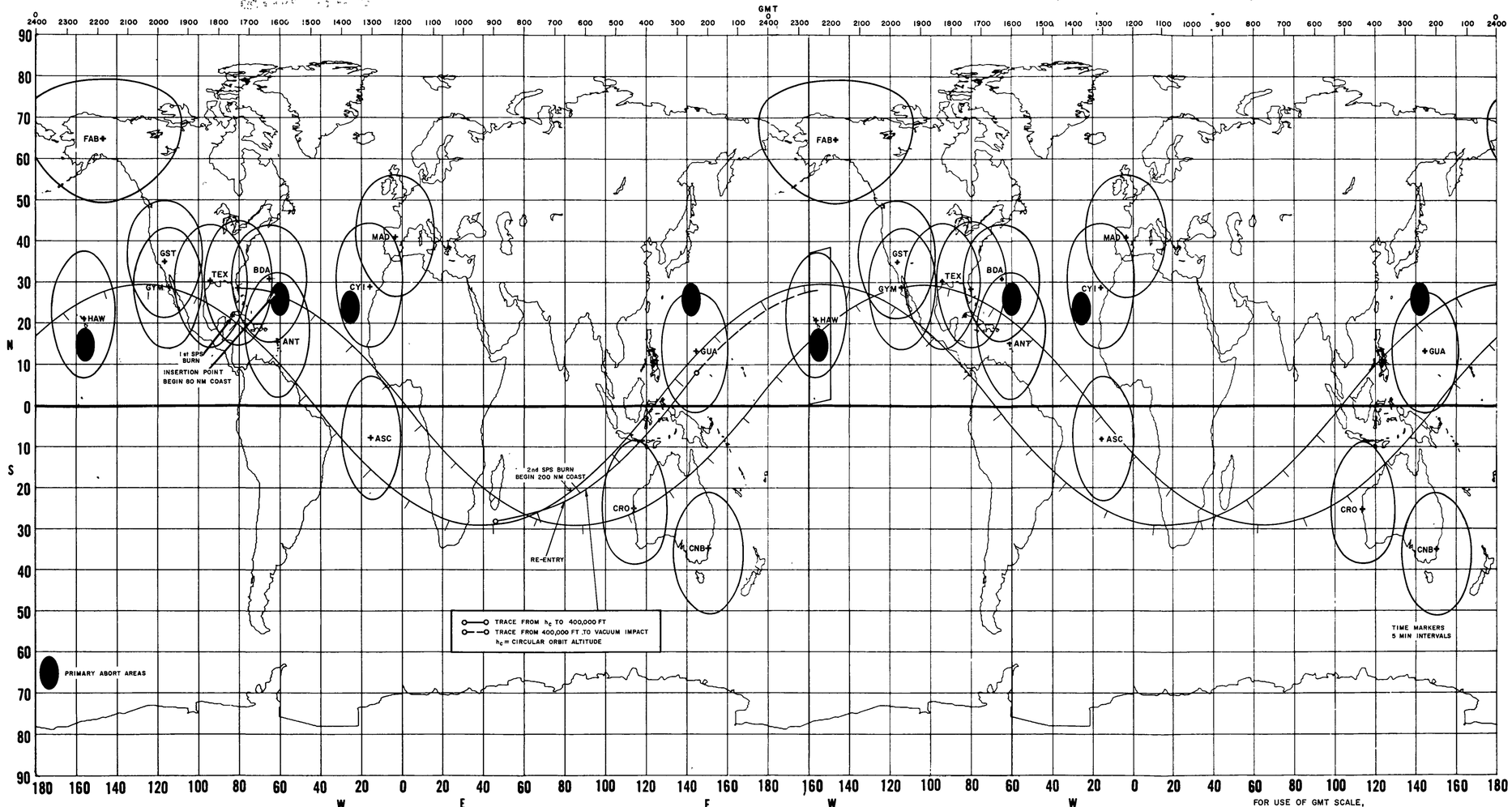
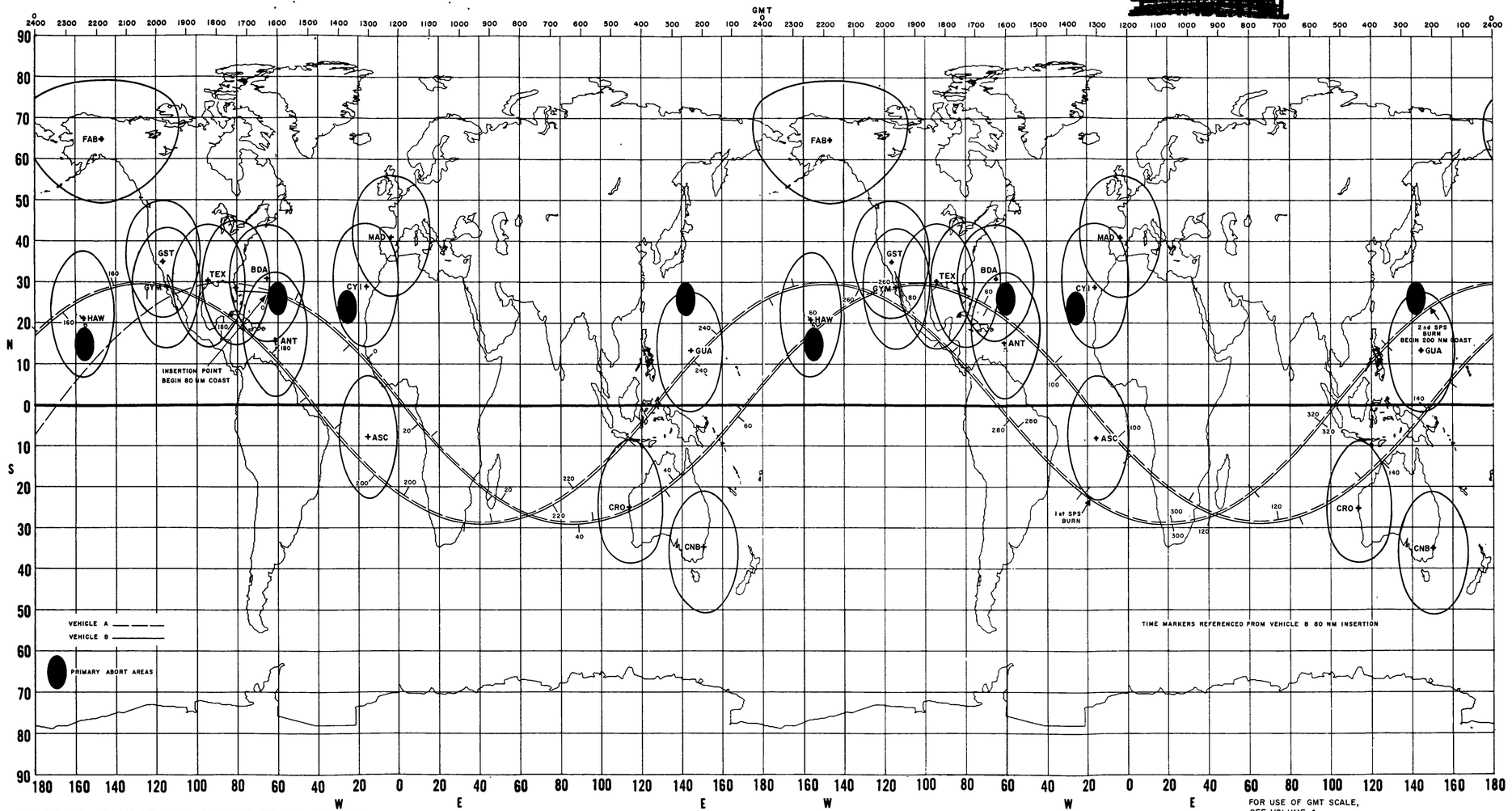


Figure 1-7. Mission 2, Vehicle A Launch, Mission Orbit Insertion and Re-entry

1-29-1

1-29-2

3



MISSION 2 - RENDEZVOUS GROUND TRACK PHASING

Figure 1-8. Rendezvous of Vehicles B and A

1.3 MISSION 3 - SYNCHRONOUS OBSERVATION POST

Mission 3, Synchronous Observation Post, establishes a space laboratory in a synchronous orbit 19,350 n. mi. above the earth. The spacecraft "hovers" over a point on the equator, stationary with respect to the earth surface. The mission duration is 45 days. Twice during the mission the spacecraft will shift its position relative to the earth surface, for a total of three hover points.

The advantages of an equatorial synchronous orbit at this mission altitude are numerous. An entire earth hemisphere, including the polar areas, can be seen, which permits simultaneous observation of such phenomena as the conjugate auroras and wind patterns in the northern and southern hemispheres. At an altitude of 19,350 n. mi. the vehicle is above the Van Allen belts, the environment approaches that of deep space, and it is feasible to examine the effects of this environment on biological organisms. Shadowing by the earth occurs only about 5 percent of the time, and almost uninterrupted observation of the sun and other astronomical bodies is possible.

1.3.1 EXPERIMENTS

The experiments for Mission 3 will evaluate space operational capabilities by deployment of a small maneuverable satellite, a solar balloon, and erection of a radio astronomy antenna. Studies will be conducted using high resolution astronomical photography and associated calibrated photometry in the X-ray, visual and infrared portion of the spectrum, and the nature of the conjugate auroral forms and geometries in the Artic and Antarctic auroral regions will be investigated. Experiments also will be conducted in bioscience (humans in a space environment, and spaceborne microorganisms). The experiments are as follows:

Experiment Number	Category
0100	Biomedical (excluding 0101 and 0102)
0200	Behavioral
0401	Microbial Genetics and Growth
0402	Microbial Development Biology
0406	Soft Capture, Enumeration, and Identification of Spaceborne Microorganisms

Experiment Number	Category
0501	Radiation Environment Monitoring
0701	Emission Line Radiometry
0702	Intermediate Size Reflecting Telescope
0703	Manned Coronagraph
0705B	Radio Astronomy
0801	Conjugate Aurora
1001	Small Maneuverable Satellite
1303	Extendible Rod Performance
1304	Solar Sailing

1.3.2 CONFIGURATION

The configuration history of Mission 3 is shown in Figure 1-9. The location of experiment equipments is shown in Figure 1-10.

The total weight of experiment equipments is about 6000 pounds, of which more than half is attributed to a telescope mounted in the descent stage of the LEM. The total volume of experiment equipments is 119 cubic feet. The average power required is 535 watts, with peaks to 1050 watts.

The weight margin, defined as the difference between the total spacecraft payload weight and the maximum allowable weight, is 3742 pounds.

1.3.3 TRAJECTORY

The space vehicle, powered by the Saturn V, is launched from AMR on an azimuth of 90 degrees. The S-IC and S-II stages are burned completely, and a partial burn of the S-IVB is used to attain the 100-n. mi. circular earth parking orbit, inclined 28.5 degrees to the equatorial plane. After 102 minutes, slightly before the third equatorial crossing, the S-IVB is reignited for a Hohmann transfer orbit insertion, with an orbital inclination of 26.5 degrees. The vehicle coasts to synchronous altitude, and the S-IVB is restarted for a third and final burn to accomplish a 17.4-degree plane change. The vehicle coasts one full earth-revolution in the intermediate orbit, where the S-IVB is jettisoned and transposition and docking occurs. The intermediate orbit has a period of 13.7 hours, an inclination of 9.1 degrees, and a perigee altitude of 5296 n. mi. At

apogee the SPS performs the additional plane change of 9.1 degrees to the equatorial synchronous orbit (orbital period, 24 hours), at 126 degrees west longitude, and the orbit is circularized.

After 10 days, the SPS deboosts a velocity increment of 130 feet per second. The resulting orbit has a perigee of 18,213 n. mi., and after four orbits the eastward drift of the spacecraft places it at 70 degrees west longitude, where the SPS is used to resynchronize the orbit. After 10 more days the same procedure is accomplished to place the spacecraft hover point at 90 degrees east longitude. These hover points were chosen because of their relationship to the earth magnetic dipole. Each hover point lies close to the plane defined by the magnetic dipole and the geographic poles, or is nearly orthogonal to the plane. No plane changes are made on the return trajectory; touchdown is on the equator. The re-entry trajectory has a 26-n. mi. vacuum perigee, and the nominal footprint is 113.5 to 130 degrees of the earth-central angle. Ground traces for Mission 3 are shown in Figures 1-11 and 1-12.

1.3.4 OPERATIONS

After the S-IC and S-II burns, and S-IVB engine cutoff in the 100-n. mi. parking orbit, the orbit is verified and the three crewmen set the controls and displays for parking orbit operations. The spacecraft systems are checked, IMU alignments are performed and verified, and the guidance computer is programmed for transfer insertion. The S-IVB ignites and places the spacecraft in the Hohmann transfer orbit with an apogee of 19,350 n. mi. The S-IVB shuts down, checkout and navigational activities are conducted, and the crew prepares for the second transfer orbit insertion maneuver. At transfer orbit apogee, the CSM GNS automatically ignites the S-IVB for an elliptic trajectory with a perigee of 5294 n. mi. and an apogee of 19,350 n. mi. The S-IVB burn includes a plane change to a second transfer ellipse of 9.1 degrees inclination. Transposition and docking is accomplished and the S-IVB is staged. The SPS is ignited for the insertion burn (304 seconds) into the 19,350-n. mi., 0-degree inclined, synchronous earth orbit. The time is T + 21 hours, 2 minutes.

The mission orbit is confirmed, the controls and displays are secured, and a CSM systems status check is conducted. Navigation sightings are conducted and compared with ground computed parameters. The LEM is pressurized and manned and the crew begins a work/rest cycle.

On the eleventh mission day, using the SM SPS, the spacecraft coasts for 3.8 days, and the SM SPS is again thrusted to replace the CSM/LEM configuration into a synchronous earth orbit at 70 degrees west longitude and 0 degrees latitude. The crew returns to its normal work/rest cycle. Experimentation is continued until the 24.8 day, when the crew prepares for a second post changing maneuver. The SM SPS is ignited, and the CSM/LEM coasts for 11.5 days before SPS thrusting replaces the spacecraft in synchronous earth orbit at 90 degrees east longitude.

At the end of the 45-day orbit phase of the mission, the LEM is staged, and the SPS is retrofired to insert the CSM into a descending transfer orbit.

SM staging occurs, and a final pre-entry check is conducted.

The re-entry phase begins at a nominal entry altitude of 400,000 feet, through a full-lift flight from 400,000 feet to a point where the rate of descent is reduced to 700 fps. The CM descends in an equilibrium glide to an altitude of 24,000 feet, where the drogue chute is deployed.

The CM earth landing system is armed at 100,000 feet. The forward heat shield is jettisoned at an altitude of 25,000 feet and the drogue chutes are deployed 3-seconds later. After 58 seconds, the drogue chutes are jettisoned and the main chutes are deployed (11,000 feet). After touchdown, the crew members perform post-landing operations and the crew egresses to await recovery.

1.3.5 CREW ACTIVITY

From launch to insertion into the 19,350-n. mi. synchronous orbit and from de-orbit to touchdown, the flight crew will monitor displays, perform IMU alignments and system status checks, control the spacecraft attitude for orbit insertion maneuvers and course corrections, and communicate with MSFN. The crew activities during each day in mission orbit include the operation of scientific experiments, and their routine spacecraft assignments. Personal functions are performed in the time remaining.

Systems status checks for the CSM and LEM average 4.75 man-hours per day, which includes activities such as fuel-cell purging, battery charging, and lithium-hydroxide cannister replacement.

The typical work/rest cycle consists of approximately 10 hours on duty and 14 hours off (6 hours sleep, 5 hours rest, and 3 hours for eating and personal hygiene).

Crew experiment activities for Mission 3 include:

a. Astronomical experiments, including the measurement of interstellar gas densities, high-resolution photography in the visual and ultravisible ranges, investigation or solar corona and conjugate auroras, and mapping of galactic noise in selected ranges. Except for the erection of a 40-inch telescope and external antenna structures, which utilizes two astronuats (one in EVA), the astronomical observations are performed by a single astronaut, generally on a daily basis.

b. In radiation monitoring, the astronauts daily observe spectrometer outputs and dosimeter readings.

c. Selected biomedical experiments, which are conducted on single subjects, evaluate the effects of space environment. Blood and urine samples are collected; blood pressure and body fluid volumes are determined; and the effects of negative pressure devices, occlusive cuffs, and isometric exercises are evaluated.

d. For development of capabilities in space, the astronauts launch, observe, and control a small satellite; observe thin extendible rods; and develop techniques for controlling orbital flight by means of solar radiation. These experiments are conducted by two astronauts. The small maneuverable satellite experiment requires considerable EVA.

e. The effects of zero-g environment on bacterial growth is evaluated by controlled investigations conducted continuously by a single crewman.

f. The behavioral experiments utilize test apparatus to evaluate sensory and perceptual processes, psychomotor functions and vigilance. Some tests require two astronauts, one subject and the other an observer; in other tests only one astronaut is required.

g. The possible presence of spaceborne organisms is investigated by self-capture "traps" which require a single astronaut in EVA for placement and recovery.

The percent of time spent by the astronauts during the first 14 days of the 19,350-n. mi. synchronous orbit phase is as follows:

Function	Time Utilization (Percent)
Experimentation	28.5
Flight Operations	10.5
Personal	57.5
Unscheduled	3.5
	100.0

Reduction in the source-recommended experiment schedule was necessary because of excessive time requirements for individual experiments. The experiment times for Mission 3 for a 45-day mission, based on the 15 day sample, are

Source-recommended Experiment Time: 1588 man-hours

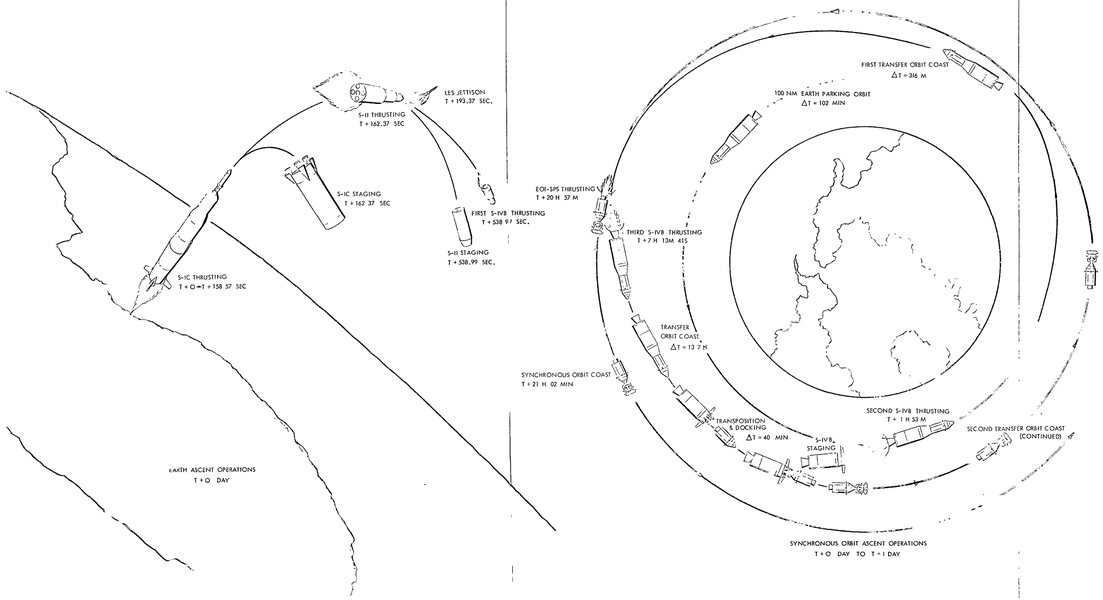
Scheduled Experiment Time: 834.3 man-hours

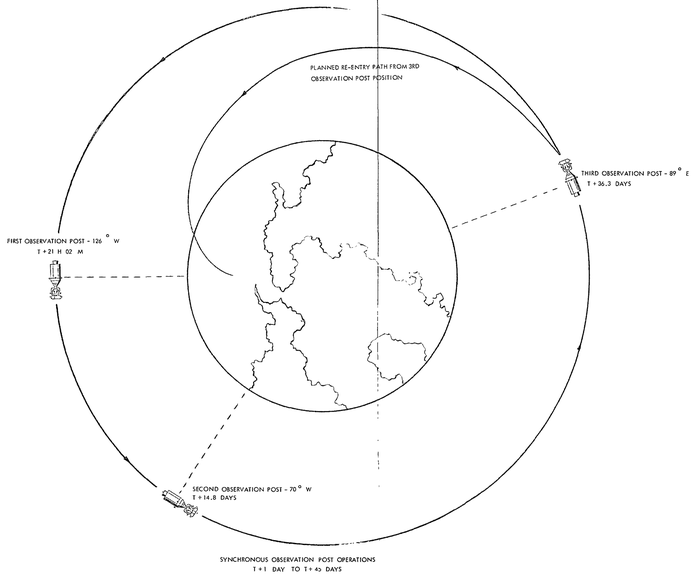
1.3.6 DATA FLOW

Mission 3 will be in continuous contact with at least one ground telemetry station for all experiment sequences; therefore, it was assumed that no inflight data recording payload buildup would occur. The total number of PCM channels in use at one time during the mission is expected to be six analog, one digital. The total minutes of recorded data will be 13,612 minutes; transmission time will be continuous.

Several forms of data are required for which detailed weight and volume estimates are not available, but accumulated data weights (film and tape) aboard the spacecraft will exceed 300 pounds, which is higher than the assumed maximum recoverable data payload weight of 250 pounds.

MISSION 3 SYNCHRONOUS OBSERVATION POST





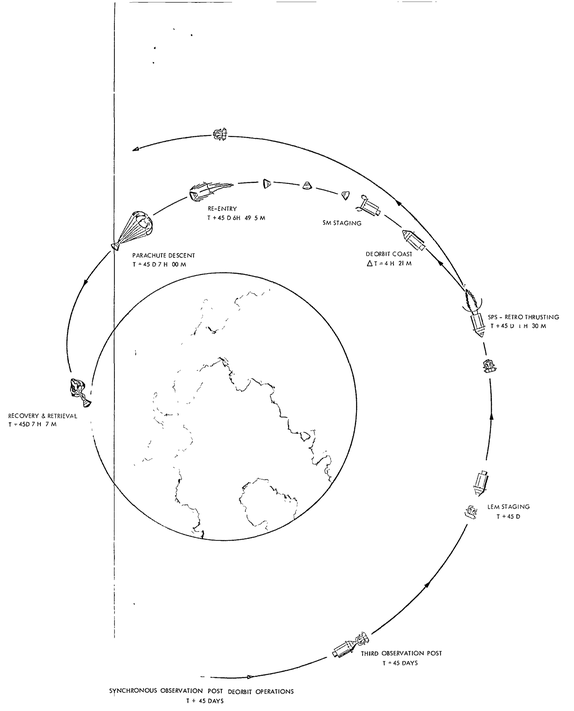


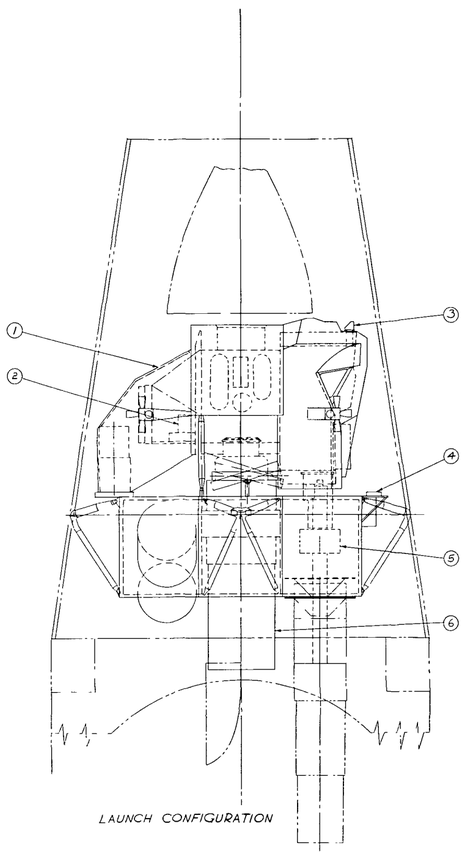
Figure 1-9. Mission 3 - Configuration History

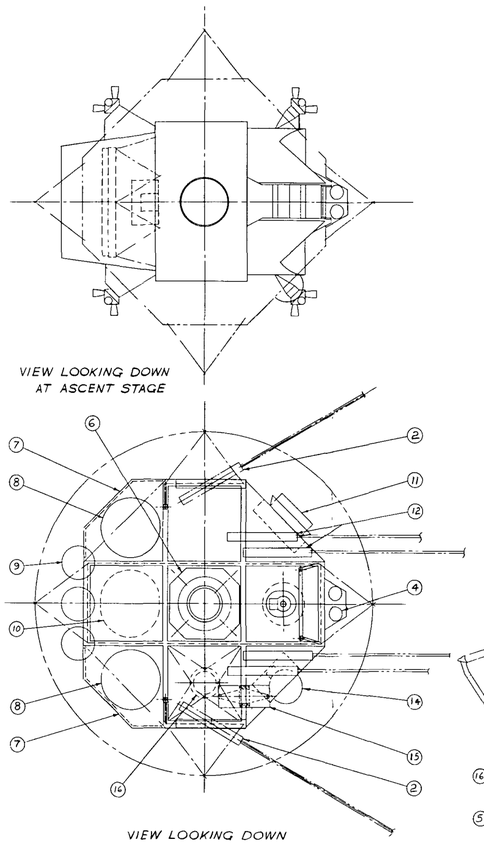
1-37-1 1-37-2 1-37-3 1-37-4

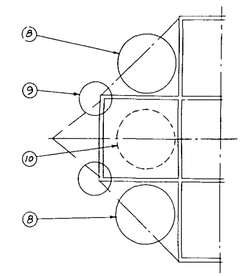
CONFIDENTIAL

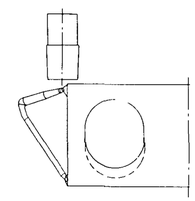
KEY

No.	Experiment	Name
1		FCA Radiator
2	0705B	Radio Astronomy 1-5 mc Range Using Tunable V-Antenna
3		Boresight Star Tracker
4	0406	Space-Borne Micro-organism Cartridges
5	0703	Manned Coronagraph
6	0702	Intermed-Size Reflecting Telescope
7		Equipt Radiator
8		H_2
9		FCA
10		O_2
11	1001	Small Maneuverable Satellite
12	1303	Extendable Rod Perf. Test
14	1304	50 Foot Balloon W/Coils, Power Supply & Canister
15	0801	Telescope Assy
16	0701	Emission Line Radiometry









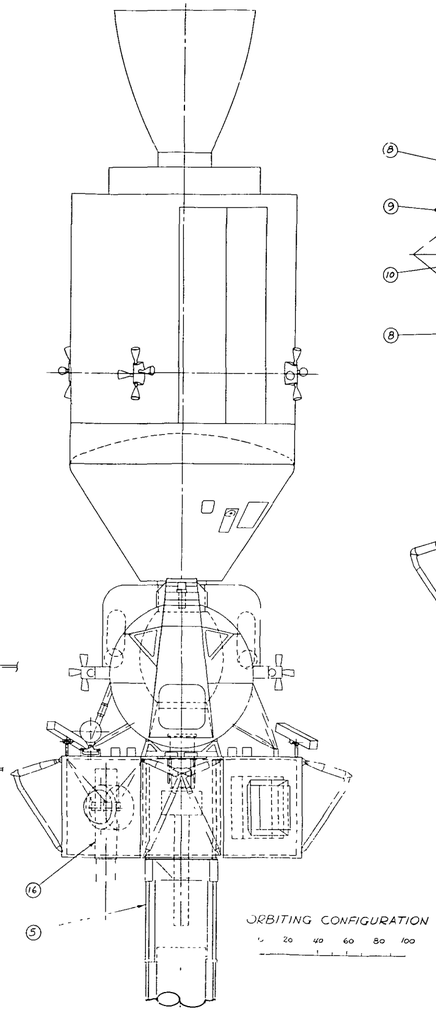


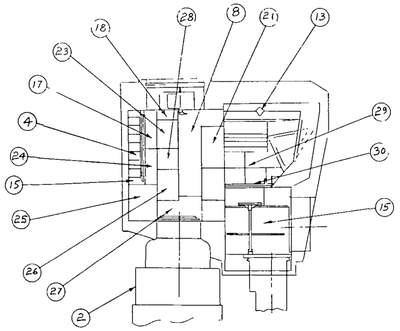
Figure 1-10. Mission 3 - Spacecraft Configuration and Experiment Location (Sheet 1 of 2) (32 pages 1-10.30)

CONFIDENTIAL

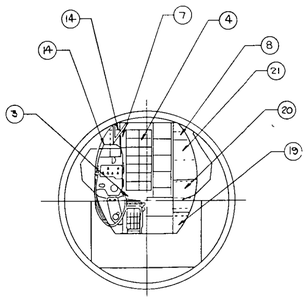
CONFIDENTIAL

KEY

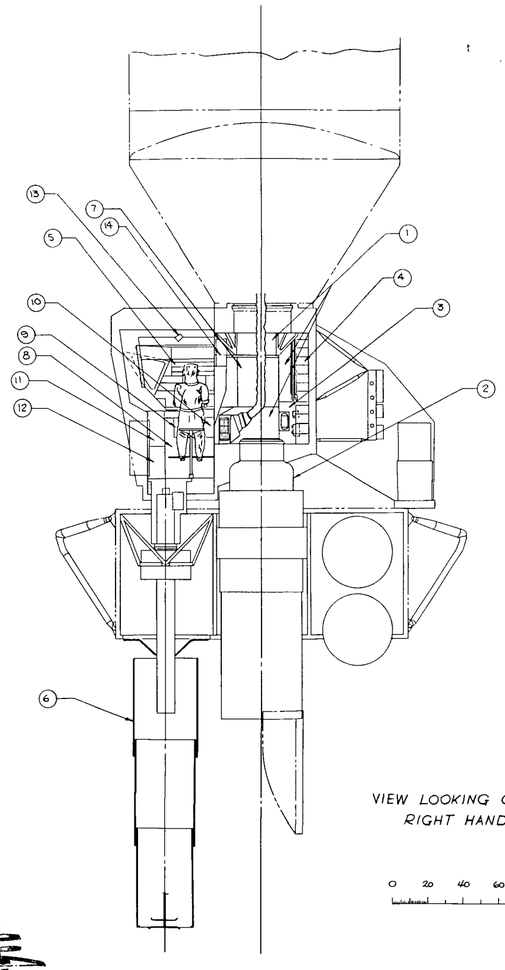
No.	Experiment	Name
1		Food
2	0702	Telescope
3	0402	-20°C Refrigerator
4		LiOH
5		Astronomers Display Console
6	0703	Coronagraph
7		ECS
8		Biomed
9	0100, 0200	Biomed Incubator
10		Biomed Refrigerator
11	0401,0402	Incubator
12	0501	Radiation Environment Monitoring
13		Floodlights (2)
14	1304	Binoculars & Range Finder
15		Logs, Film & Tape Storage, Recorders
16		Seat & Restraint (2)
17	0406	+5°C Refrigerator
18	0401	Lyophilization
19	0401	Chemical Equipment Storage
20	0402	Scintillation Counter
21	0402	Cultrue Flasks
22		ECS & Communications Control Console
23	0401,0402 0406	Microscope
24	0401,0402	-15°C Refrigerator
25	0406	Incubator
26	0402	Particule Counter
27	0402	Support Cabinet & 35mm Camera
28	0402	Centrifuge
29	0801,1001	Display
30	1303,1304 0801,& 1001	Control Console



VIEW LOOKING OUTBOARD
LEFT HAND SIDE

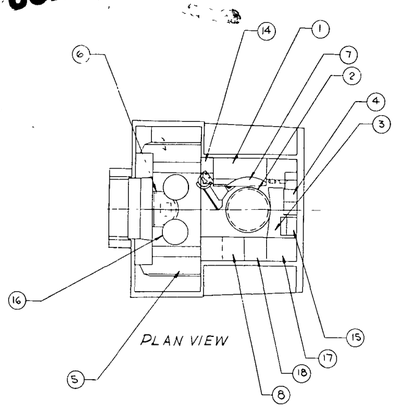


VIEW LOOKING AFT

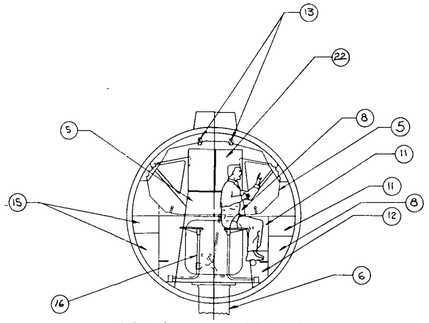


VIEW LOOKING OUTBOARD
RIGHT HAND SIDE

0 20 40 60 80 100



PLAN VIEW



VIEW LOOKING FORWARD

Figure 1-10. Mission 3 - Spacecraft Configuration and Experiment Location
(Sheet 2 of 2)
(32 pages 1-10.30)

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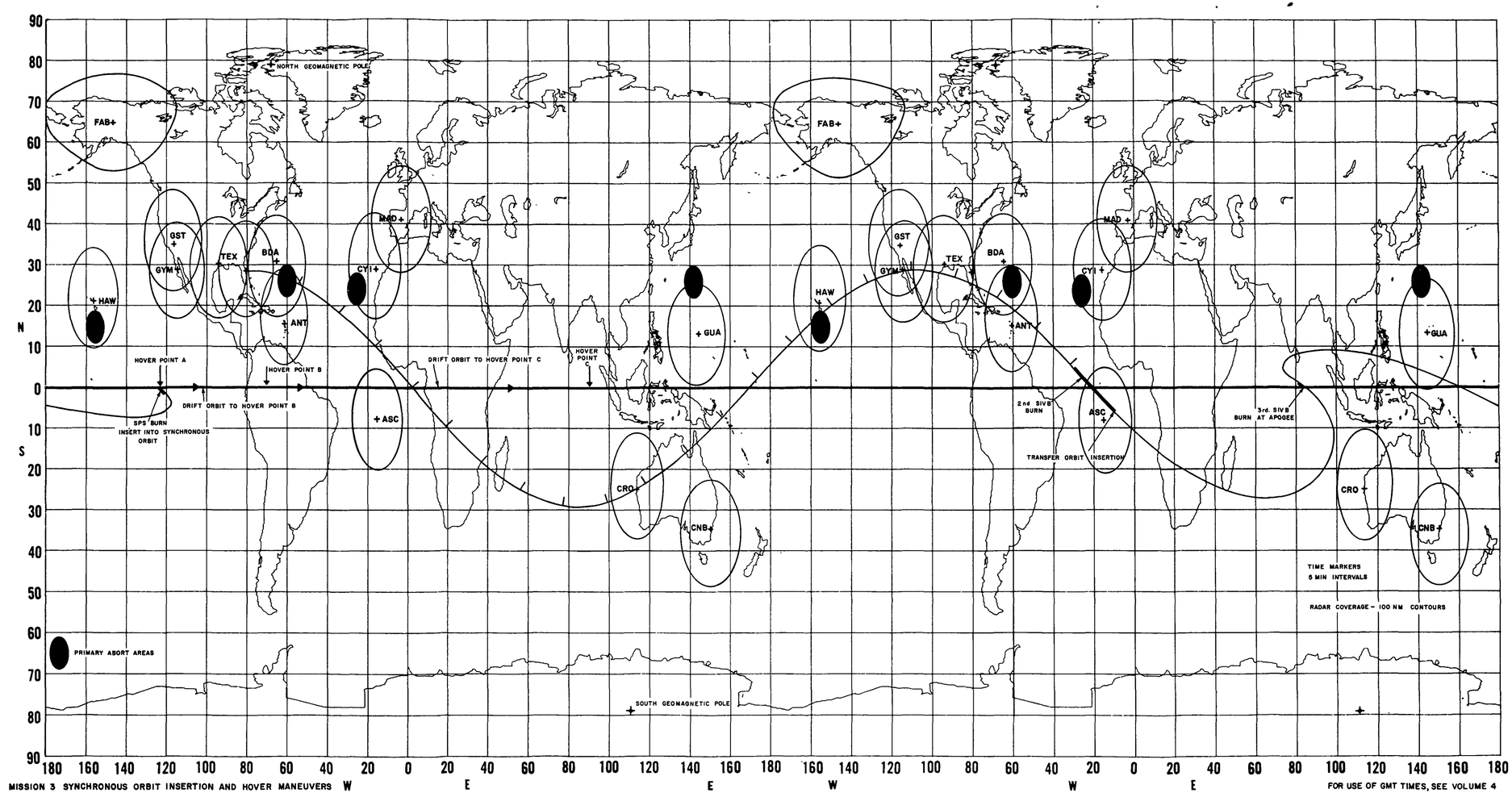


MISSION 3 SYNCHRONOUS ORBIT INSERTION AND HOVER MANEUVERS

FOR USE OF GMT TIMES, SEE VOLUME 4

Figure 1-11. Launch and Mission Orbit Insertion Ground Trace

1-41-1

1-41-2

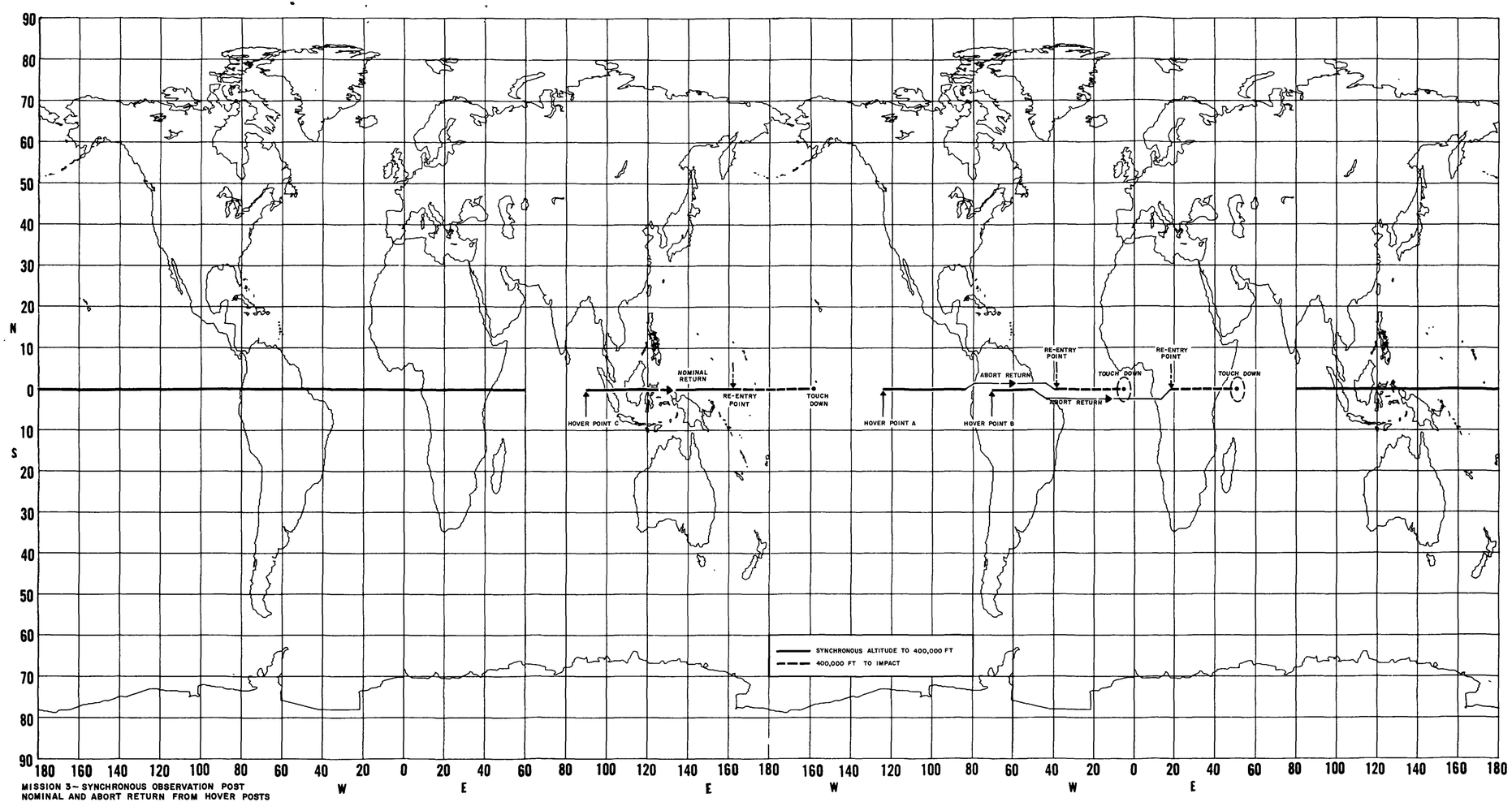


Figure 1-12. Re-entry Ground Trace

-1

142-2

142-3

1.4 MISSION 4 - NEAR-POLAR RETROGRADE SURVEY

The Near-Polar Retrograde Survey mission is planned for a 45-day duration at an altitude of 200 n. mi. and an inclination of 96.5 degrees. At this orbital altitude, an instrument with a 45-degree field of view will cover a 120-mile band at the subsatellite point. As shown in Figure 1-13, the entire surface of the earth could be completely viewed in six days and every point would be covered 11 times during the mission. The spacecraft orbit at this inclination is sun-synchronous; that is, the orbit is fixed inertially with respect to the sun, and the lighting angle at a point directly below the vehicle varies only with latitude.

1.4.1 EXPERIMENTS

The experiments for this mission will deploy multispectral sensors on a global basis for (1) verification of earth-sensing techniques using ground truth sites; (2) collection of scientifically and commercially useful data of uncharted regions; and (3) further development of advanced space meteorological equipment.

The experiments are as follows:

Experiment Number	Category
0100	Biomedical (excluding 0101 and 0102)
0200	Behavorial
0501	Radiation Environment Monitoring
0802A	High-Resolution Infrared Radiometer
0802B	Test of Infrared Scanning Spectrometer
0802C	Test, Calibration and Evaluation of Microwave Spectrometer
0802D	Test of a Prototype Star-Tracker
0901	Multispectral Target Characteristics
0902	Synoptic Earth Mapping
0903	Multifrequency Radar Imagery
1405	Large Solar Cell Array
1407	Onboard Guidance and Navigation

1.4.2 CONFIGURATION

The configuration history for Mission 4 is shown in Figure 1-14. Mission times are provided relating time to the configuration changes. The location of experiment equipments is shown in Figure 1-15.

The total weight of experiment equipment is about 5200 pounds, of which half is for mapping and radar experiments. The average power required for experiments is 487 watts, with peaks to 1160 watts. The spacecraft weight margin for Mission 4 is 31,122 pounds. A significant amount of the SM RCS propellant load for this mission is required to support the experiment package.

1.4.3 TRAJECTORY

Mission 4 utilizes the Saturn V launch vehicle to place the payload into a 200-n. mi. orbit, at 96.5 degrees inclination. The launch phase crosses the southern coast of Florida in a launch azimuth of 146 degrees from Cape Kennedy. The yaw program of one-degree per second is used between 120-to-150 and 159-to-184 seconds to achieve a direct ascent into mission orbit. Orbit insertion occurs at about 3.2 degrees south latitude, 88.8 degrees west longitude.

The desired 45-degree angle to the sun, for survey camera operation, is a constraint on launch time. For this study a launch time was assumed.

The experiment constraints are as follows:

Seasonal:	Midwinter/Midsummer
Vehicle Orientation:	Earth pointing, 45-degree sun angle
Stabilization:	± 0.2 degrees, for 540 hours; ± 5 degrees, for 540 hours
Ephemeris accuracy:	10 feet

A ground trace of Mission 4 is shown in Figure 1-16.

1.4.4 OPERATIONS

Orbital operations for this mission are direct adaptations of standard Apollo maneuvers. The transposition and docking maneuvers take place immediately after ascent into mission orbit. Flight operations from this time until LEM jettison are in support of the experiments. The LEM is jettisoned prior to the de-orbit maneuver (performed with SPS thrust) and remains in orbit.

1.4.5 CREW ACTIVITY

The flight crew duties consist of display monitoring, controlling the spacecraft during the transposition and docking maneuver, performing IMU alignments and systems checks, controlling the spacecraft attitude for the de-orbit insertion maneuvers, and communicating with the MSFN. During each day of the mission orbit phase, the crew activities also include the responsibilities of the scientific experiments. Personal functions are performed in the time remaining.

Systems status checks for the CSM and LEM average 4.75 man-hours per day, including activities such as fuel-cell purging, battery charging, and lithium hydroxide cannister replacement. IMU alignments are performed eight times per day during this mission.

The typical work/rest cycle consists of approximately 10 hours on duty, 14 hours off (6 sleep, 5 hours rest, and 3 hours for eating and personal hygiene).

Experiment activities scheduled for Mission 4 include:

a. Evaluations and assessments of onboard guidance and navigation systems and components. One astronaut is required to operate and conduct studies in stellar navigation, landmark navigation, and horizon and altimeter/ Doppler sensing techniques.

b. Two, and sometimes three, astronauts are required to set up the experiments and load the cameras (every three days) for gathering multispectral target characteristics, multifrequency radar imagery, and synoptic earth mapping. The experiment operation requires one astronaut, operating and monitoring the cameras.

c. Monitoring thermal radiation, testing infrared and microwave spectrometers, and demonstrating the ability of a prototype startracker to "lock on" and track stars of the fourth magnitude, require one astronaut four times daily, except in the startracker use, which is performed approximately once per week.

d. Selected biomedical experiments, which require one subject at a time, evaluate the effects of the space environment. Blood and urine samples are collected; blood pressure and body fluid volumes are determined; and the effects of negative pressure devices, occlusive cuffs and isometric exercises are evaluated.

e. For deployment and study of solar cell array, considerable time is required of two astronauts for setup and checkout, although only one man is required for daily data record taking.

f. The behavioral series of experiments utilize console-stored test apparatus to evaluate sensory and perceptual processes, psychomotor functions, and vigilance. Certain tests require two astronauts, one as subject and the other as observer; in other tests, only one astronaut is required.

The distribution of astronaut time for various functions during the first 14 days of the mission orbit phase is as follows:

Function	Time Utilization (Percent)
Experiments	24.2
Flight Operations	13.9
Personal	57.4
Unscheduled	4.5
	100.0

Deviations from the source-recommended experiment schedules were required where time requirements exceeded the time available. The proposed experiment times and the projected experiment time scheduled for 45-days, based on the 14-day sample, are:

Source-Recommended Experiment Time:	1790 man-hours
Scheduled Experiment Time:	786 man-hours

1.4.6 DATA FLOW

The average telemetry coverage is 14 percent, assuming that only contacts of four minutes or longer are counted, and that a tracking station will be located at Fairbanks, Alaska. Noncoverage intervals greater than 120 minutes will occur an average of once every three days. (Without the Fairbanks station, coverage would be only 11 percent, and noncoverage intervals would occur twice a day.) A great deal of available transmission time is wasted during Mission 4, especially on the first day. Recording tape backlogs are not scheduled to be accumulated before starting the lengthy solar cell deployment procedure in experiment 1405. This experiment should be rescheduled for later in the mission.

Mapping film accumulates rapidly throughout the mission. Late in the mission, reels of excess tape are accumulated at the rate of approximately 8 reels a day. This accumulation rate is a serious problem. The recoverable data payload required for Mission 4 is over 2100 pounds, which is eight times greater than the assumed recoverable payload capability. Almost 20,000 total minutes of data will be recorded during Mission 4, and the transmission time available is less than 10,000 minutes.

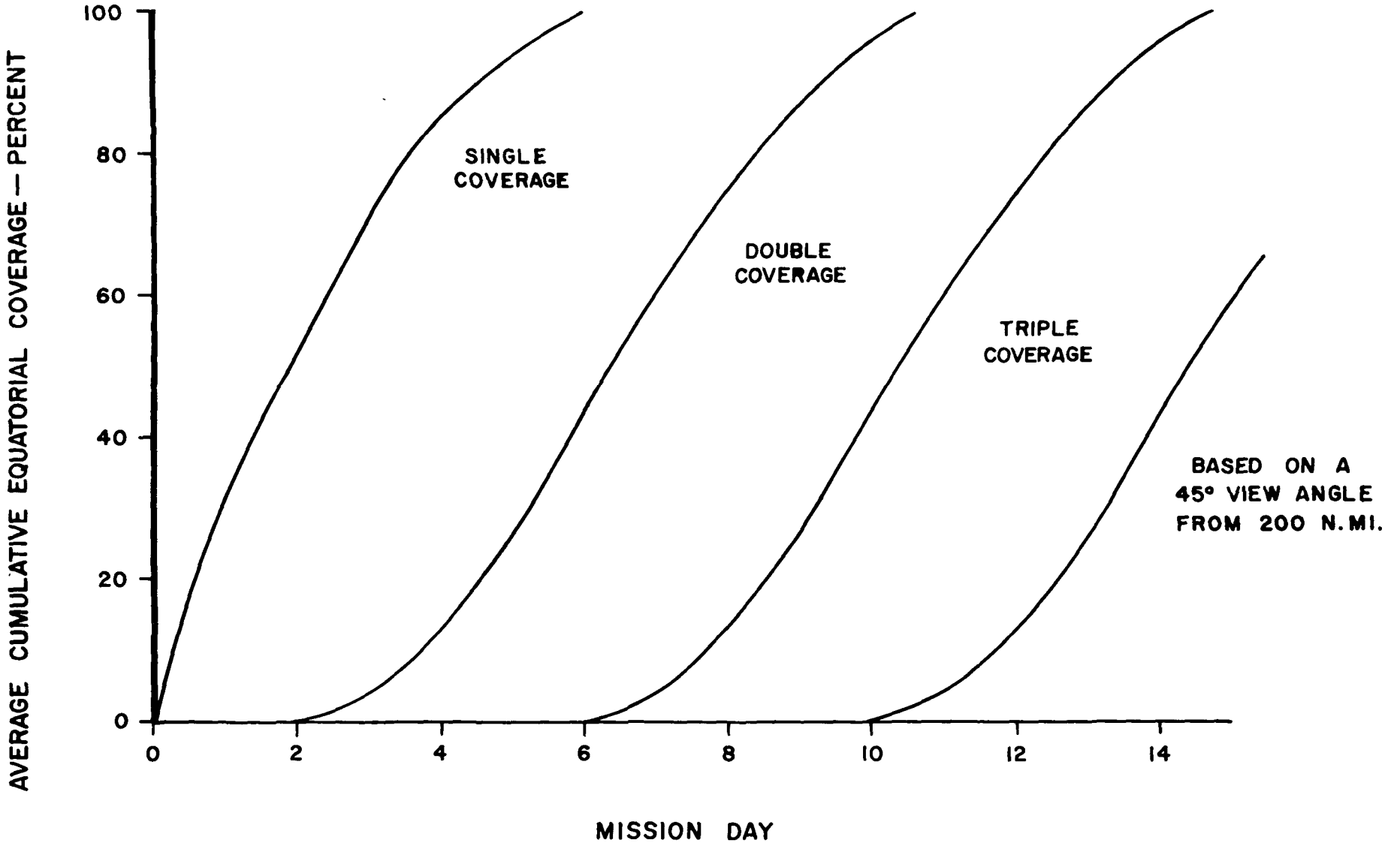
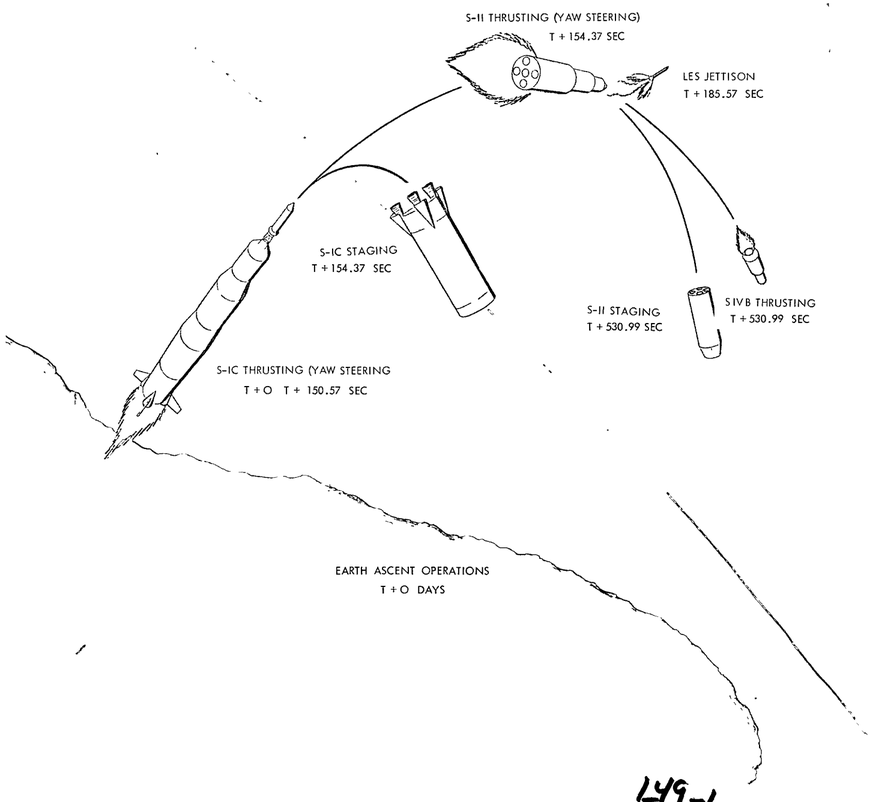
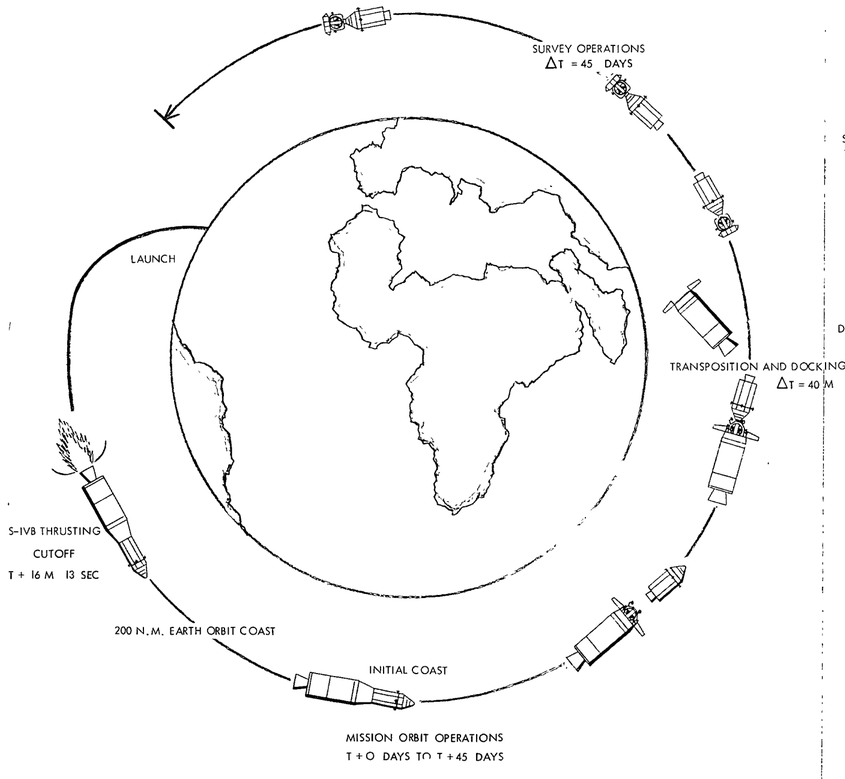


Figure 1-13. Cumulative Equatorial Orbital Surface Coverage Buildup in a Near-Polar Inclination

MISSION 4 NEAR-POLAR RETROGRADE SURVEY



L49-1



L49-2

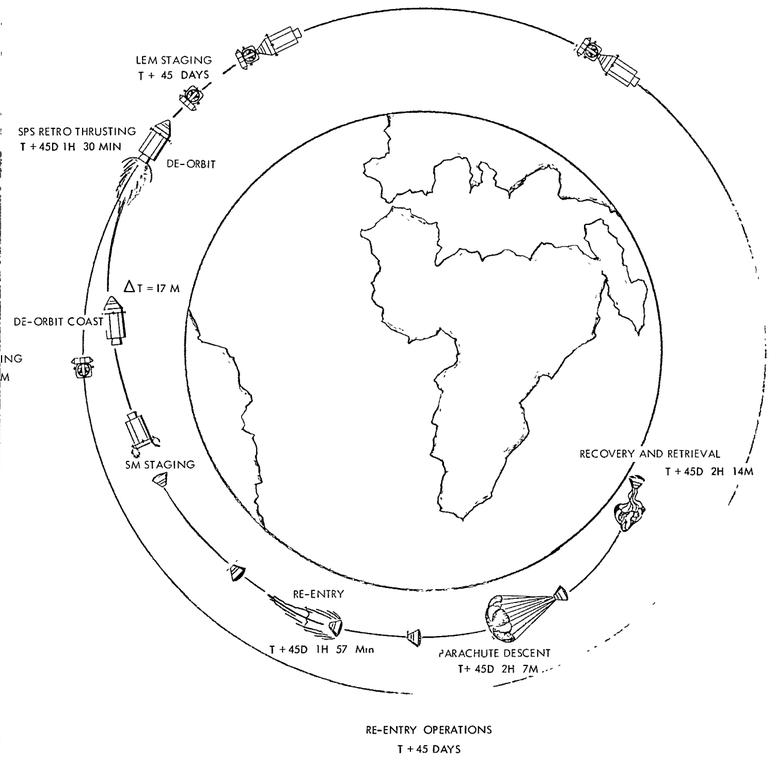
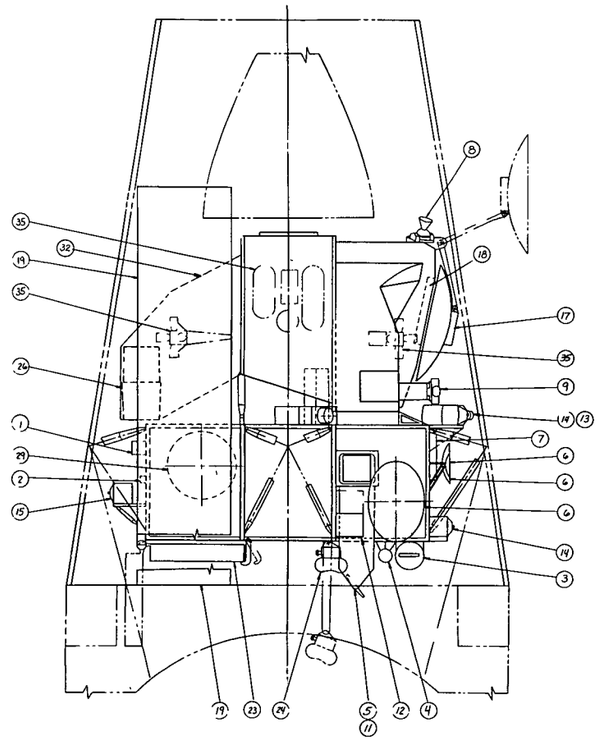


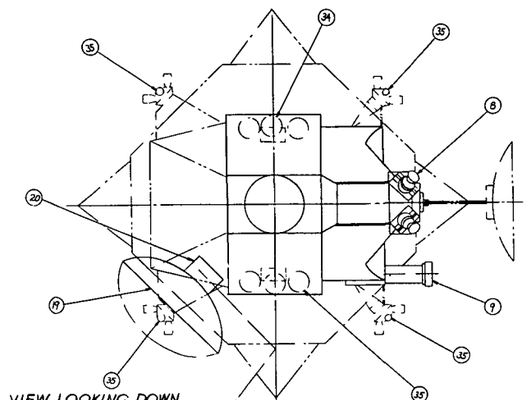
Figure 1-14. Mission 4 - Configuration History

KEY

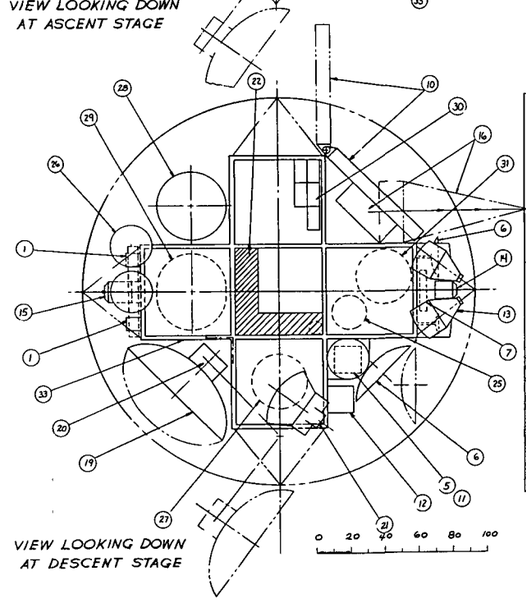
No.	Experiment	Name
1	501	Electron Spectrometer (2)
2	501	Proton Alpha Spectrometer
3	802A	IR Radiometer (Also use on 901-2B in place of Spectro/photometer)
4	802	Ceramic Sphere
5	901,802B	Use 901 Grating Spectrometer & Telescope (replaces 802B IR, Near IR, and UV-vis spectrometers
6	802C	12-in., 24-in., & 48-in. Antennas
7	802C	Receivers 10-18 GC 40-50 GC 18-26 GC 49-59 GC 26-40 GC
8	802D	Theodolites
9	902,802D	Viewfinder
10	901	Microwave Imager Antenna
11	901,802B	Grating Spectrometer & Dewar (Use on 802B)
12	901	Multispectral Camera
13	902	24-in. Fl Camera (2)
14	902,802A,802B	6-in. Fl Camera (3)
15	902	70-mm Star Camera
16	902	VHF Pulse Radar Antenna
17	902	Microwave Radiometer
18	903	Altimeter
19	903	Antenna (Folded on 8 D FLT only, otherwise 1 piece construction)
20	903	Electronics (4 cu ft)
21	903	Panoramic Camera
22	802,901 902,903	Electronics Equipt Bay
23	1405	Solar Cell Array
24	1405	16mm Movie Camera & TV Camera
25		GOX
26		FCA
27		H_2 (Block II Tank)
28		H_2 (Block III Tank)
29		O_2 (Block III Tank)
30		LiOH
31	901,902 903,802	Cryogenic Cooling
32		Radiators (FCA)
33		Radiators Equipt
34		RCS He (on 11 D only)
35		RCS (on 11 D only)



LAUNCH CONFIGURATION

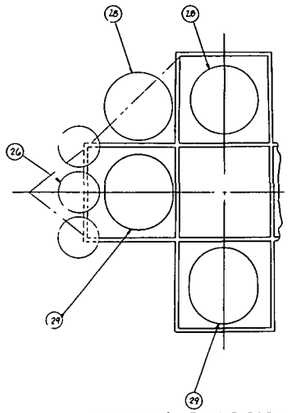


VIEW LOOKING DOWN AT ASCENT STAGE

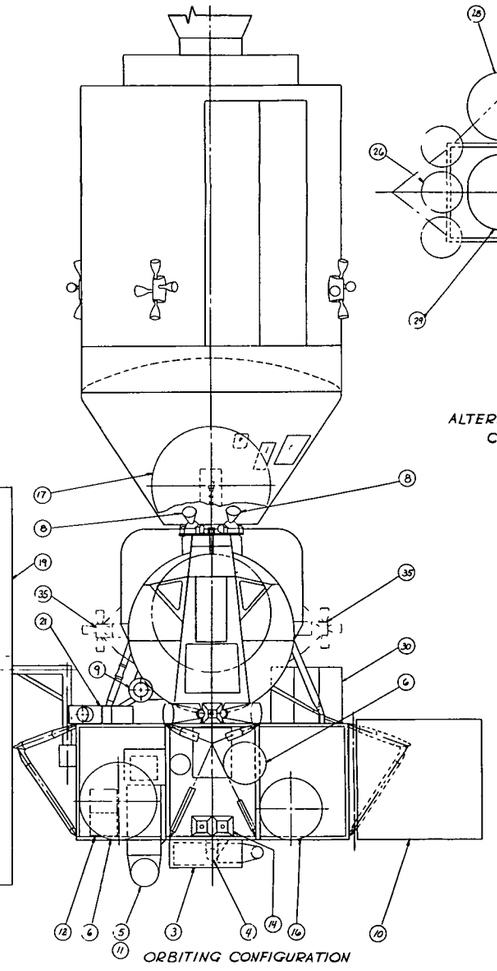


VIEW LOOKING DOWN AT DESCENT STAGE

0 20 40 60 80 100



ALTERNATE POWER PACK CONFIGURATION



ORBITING CONFIGURATION

Figure 1-15. Spacecraft Configuration and Experiment Location (Sheet 1 of 2) (33 Pages 1-11.25)

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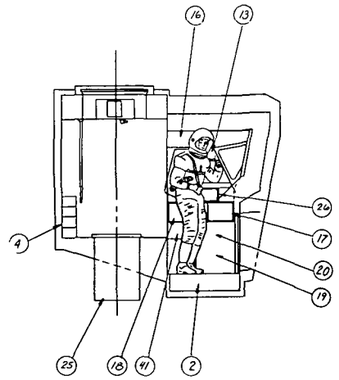
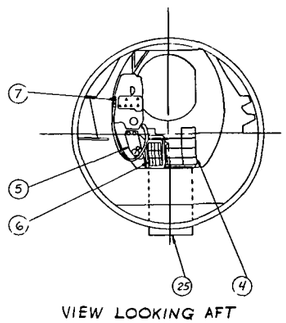
KEY

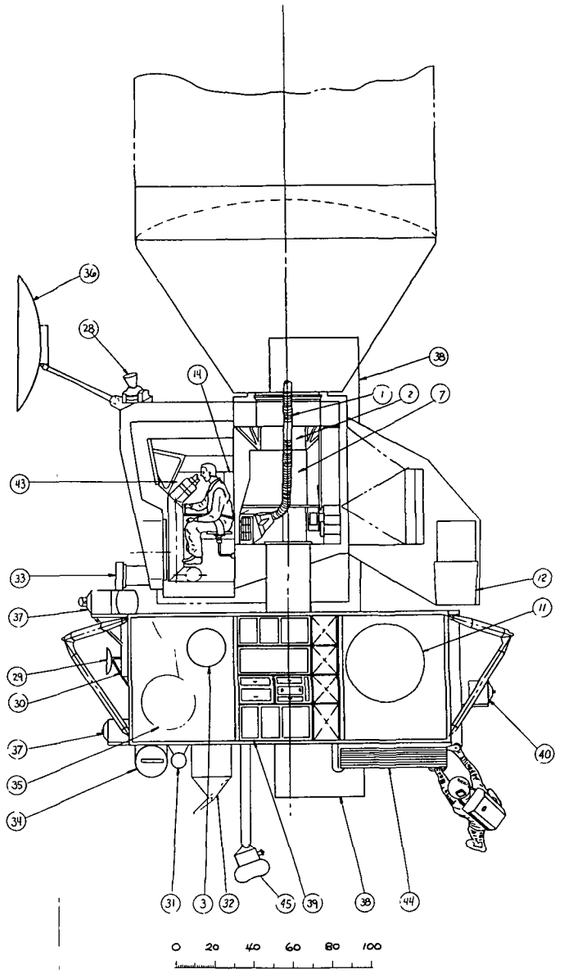
No.	Experiment	Name
1		Air Duct
2		Food
3		GOX Tank (Accumulator)
4		LiOH
5		Water Module
6		Fan
7		ECS
8		Seat
9		Flood Lights
10		Adjustable Work Top
11		O_2 (SOX)
12		Fuel Cell Assy
13		Pwr Gen & Dist Panel
14		Cryogenic Panel
15		Computer Input Panel
16		Circuit Breaker Panel
17		Digital Computer
18		Data Receiver
19		Film & Tape Storage
20		Log & Data Book
21		Tape Recorder
22	0100&0200	Biomed Incubator
23		Biomed Refrigerator
24		Biomed Panel
25	0100&0200	Biomed Storage
26	0501	Pulse Height Analyzer
27	0501	Radiation Envir Monitor Panel
28	0802D	Theodilite
29	0802C	Antenna
30	0802C	Receivers
31	0802	Ceramic Sphere
32	901,802	Telescope
33	902,802D	Viewfinder
34	901-2B, 802A	IR Radiometer
35	901,802	Cryogenic Tank (Cooling)
36	902	Microwave Radiometer
37	902	Mapping Cameras
38	903	Antenna
39	901,902, 903	Electronics
40	902	70mm Star Camera
41	1405	Pyrheliometer
42		Multimeter
43		Solar Cell Array Readout Panel
44		Solar Cell Array
45	1405	Camera



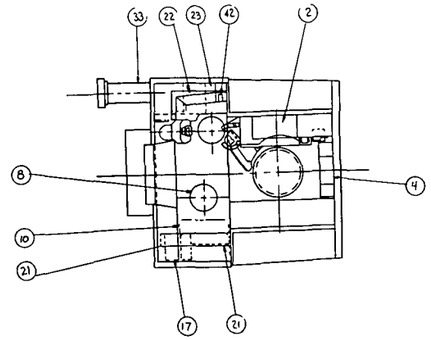
VIEW LOOKING OUTBOARD
LEFT HAND SIDE



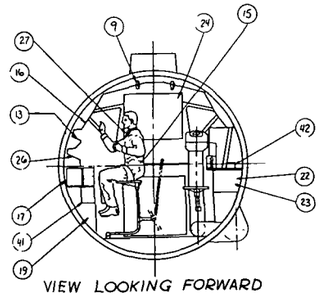
VIEW LOOKING AFT



VIEW LOOKING OUTBOARD
RIGHT HAND SIDE



PLAN VIEW



VIEW LOOKING FORWARD

Figure 1-15. Spacecraft Configuration and Experiment Location (Sheet 2 of 2) (33 Pages 1-11.26)

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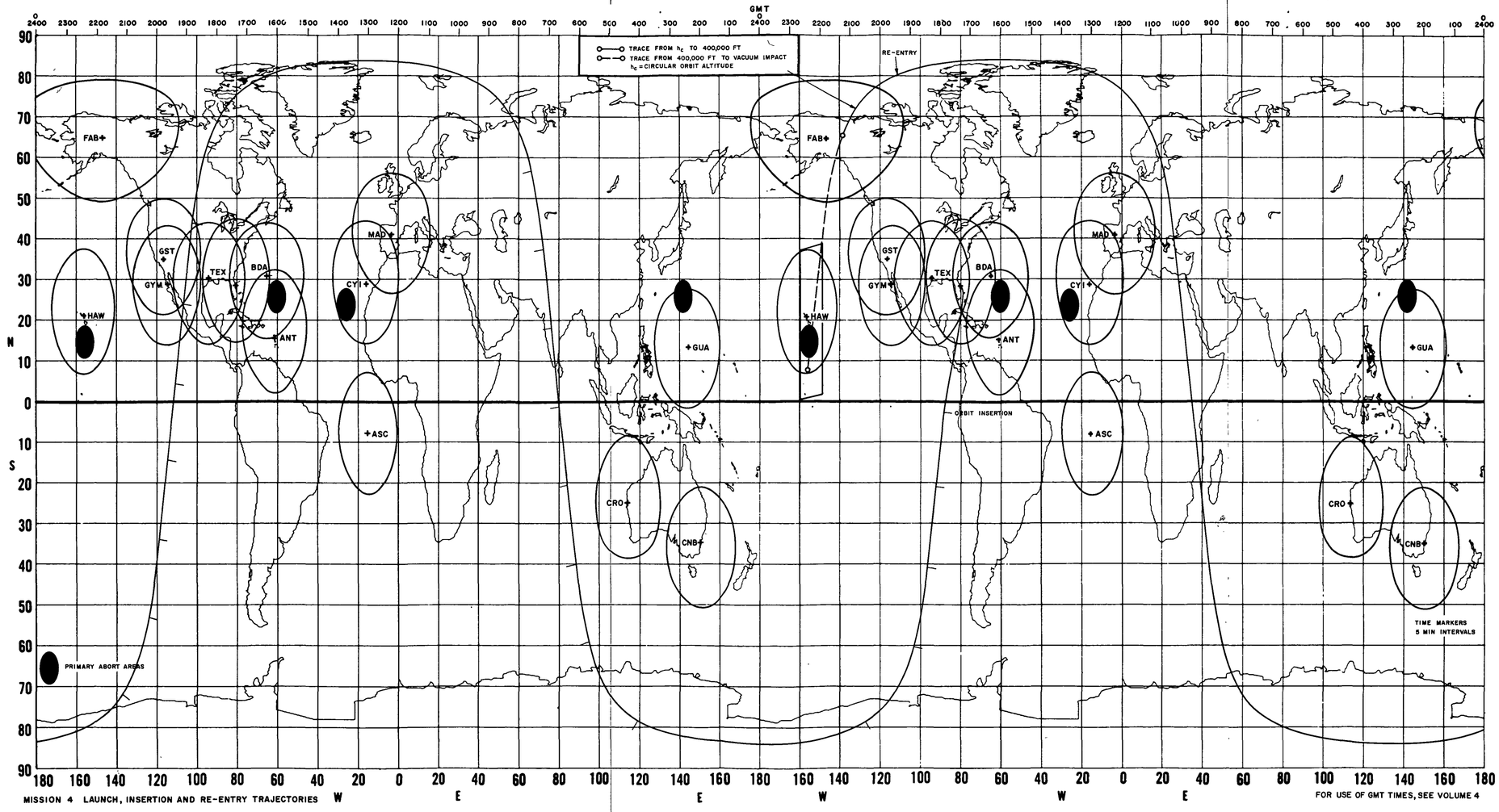


Figure 1-16. Launch and Mission Orbit Insertion Ground Trace

1-53-1

1-53-2

1.5 MISSION 5 - SATURN V TO SATURN IB RENDEZVOUS

Mission 5, Saturn V to Saturn IB Rendezvous, will continue astronomical studies begun on previous missions, gather data on living organisms in a space environment, conduct other experiments in the sciences and in space structures technology, and study spacecraft personnel and cargo transfer operations.

A first spacecraft, "A," consisting of an Apollo Block II CSM and LEM/LAB will be placed in a nominal 200-n. mi. circular earth orbit at an inclination of 29.5 degrees, by direct ascent, using the three stages of the Saturn V launch vehicle. The spacecraft will carry a crew of three and mission expendables and subsystems to permit operations for 45 days in orbit.

Thirty-five to 45 days after the launch of Spacecraft A, a second spacecraft, "B," will be placed in a similar orbit, using a Saturn IB launch vehicle to achieve an 80-n. mi. parking orbit, and the SPS to achieve the mission orbit. The two spacecraft will rendezvous and transfer predesignated personnel and materiel. The A CSM will separate from the LEM-A/Spacecraft B configuration, de-orbit, and return to earth for recovery. Spacecraft B/LEM-A will remain in orbit for 45 additional days.

1.5.1 EXPERIMENTS

1.5.1.1 Spacecraft A

Twenty types of experiments in astronomy and bioscience are planned for the first flight of Mission 5:

Experiment Number	Category
0100	Biomedical (excluding 0101 and 0102)
0200	Behavioral
0501	Radiation Environment Monitoring
0504	Micrometeoroid Collection
0601	Capillarity Studies
0602A	Kinetics and Dynamics of Vapor/Gas Bubbles
0602B	Liquid Drop Dynamics Studies
0603A	Pool Boiling in Long-Term Zero-g
0603B	Nucleate Condensation of Fluids in Zero-g

Experiment Number	Category
0604	Density Gradient of Fluids at Near-Critical States
0605	Crystallization Studies
0606	Cosmic Ray Emission
0701	Emission Line Radiometry
0702	Intermediate Size Reflecting Telescope
0703	Manned Coronagraph
0704	Gamma and X-ray Telescope
0705A	Effects of Space Environments on Structures
1302	Deployment of RF Reflective Structures
1401	Personal Hygiene and Fuel Technology
1504	Development of Personnel and Cargo Transfer Operations

1.5.1.2 Spacecraft B

There are six types of experiments planned for Flight B, in conjunction with the 20 of the first flight. The experiments are in astronomy, space logistics, and bioscience as follows:

Experiment Number	Category
0401	Microbial Genetics and Growth
0402	Development Biology
0403	Mammalian Physiology
0404	Limb Regeneration and Wound Healing
0405	Effect of Drugs on Mammalian Behavior
0406	Soft Capture, Enumeration, and Identification of Spaceborne Microorganisms

1.5.2 CONFIGURATION

The configuration history for Mission 5 is shown in Figure 1-17, the location of equipment for experiments is shown in Figures 1-18 and 1-19.

The total weight of experiment equipment for the first flight is 8948 pounds, of which 3680 pounds is required for the telescope. The equipment volume is 217.91 cubic feet. The experiments require an average power of 680 watts, with peaks to 790 watts.

Spacecraft B experiment equipment weighs 1298 pounds and has a volume of 77.47 cubic feet.

The spacecraft weight margins for this mission are 22,490 pounds for Spacecraft A (as limited by the stack limit above the S-IVB and IU stages) and 1965 pounds for Spacecraft B.

1.5.3 TRAJECTORY

1.5.3.1 Vehicle A

A ground trace for Mission 5 is shown in Figure 1-20.

The first space vehicle is launched from Cape Kennedy, using all three stages of the Saturn V, at an azimuth of 83 degrees, into the 200-n. mi. mission orbit, inclined 29.5 degrees to the equatorial plane. The insertion characteristics are as follows:

Latitude	22.15 degrees north
Longitude	42.97 degrees west
Relative Azimuth	109.7 degrees
Velocity	25,231 feet per second
Mission Time	T +1014.32 seconds

All maneuvering necessary to align the spacecraft in near proximity to each other for terminal rendezvous and docking is accomplished by Spacecraft A.

1.5.3.2 Vehicle B

The second space vehicle is launched from Cape Kennedy into an 80-n. mi. circular parking orbit using a Saturn IB. The launch azimuth and the inclination of the parking orbit will be based on mission requirements, but the parking orbit will be between 28.5 and 31.5 degrees, based on a plane-change capability of one degree. This one-degree plane change capability is critically dependent on orbital rendezvous fuel requirements. Vehicle B performs transposition and docking in the parking orbit, stages the S-IVB, and then transfers on a Hohmann ellipse to the 200-n. mi. mission orbit utilizing the SPS for thrust. Rendezvous occurs in the mission orbit with Spacecraft A performing the maneuvers. After the docking of the two vehicles, the requisite cargo and personnel are transferred and the vehicles continue to orbit in a docked condition.

1.5.4 OPERATIONS

Space Vehicle A is launched directly into the 200-n. mi. mission orbit where transposition and docking is accomplished, and the S-IVB is staged. The interlock and LEM are pressurized and manned, and upon completion of the required LEM subsystem checks, the astronauts begin a work/rest cycle. The crewmen assume their normal spacecraft responsibilities until several orbits prior to the launch of Space Vehicle B during the forty-fourth mission day. (Launch of the second vehicle can be scheduled as early as the thirty-fifth day to allow for launch date slippage. Mission times would advance accordingly.)

Vehicle B accomplishes transposition and docking during the parking orbit. Shortly after a hard dock is made between CSM B and LEM B, the Vehicle B S-IVB is staged.

After three hours in parking orbit, the SPS inserts Spacecraft B into a co-planar Hohmann transfer orbit with an apogee of 200 n. mi. Spacecraft A and B rendezvous, and dock in a LEM-to-LEM docked configuration, while the planned crew and materiel transfers are completed. The CSM A crew effects a separation from the CSM B/LEM A-LEM B configuration, which continues in the 200-n. mi. mission orbit for the following 45 days of the mission.

1.5.5 CREW ACTIVITY

The primary operational duties of Mission 5 flight crews, A and B, include display and control monitoring, controlling the spacecraft during transposition and docking maneuvers, performing IMU alignments and systems status checks, controlling the spacecraft attitude for the de-orbit insertion maneuver, and communicating with MSFN.

Systems status checks for the CSM and LEM average 4.75 man-hours per day, including such activities as fuel-cell purging, battery charging, and lithium hydroxide cannister replacement.

The typical work/rest cycle consists of approximately 10 hours on duty and 14 hours off (6 hours sleep, 5 hours rest, and 3 hours for eating and personal hygiene).

Experiment activities scheduled for Flight A of Mission 5 include:

a. Astronomical observations, measurements of interstellar gas densities, high resolution photography in the visual and ultraviolet range, investigation of solar corona, study of nearby solar-like stars, and mapping of

galactic noise in selected ranges. With the exception of the erection of a 40-inch telescope and external antenna structures, which requires two astronauts (one in EVA), the astronomical observations are performed by a single astronaut, generally on a daily basis.

b. Selected biomedical experiments, conducted on one subject evaluate the effects of the space environment. Blood and urine samples are collected; blood pressure and body fluid volume changes are noted; and the effects of negative pressure devices, occlusive cuffs, and isometric exercises are evaluated.

c. In radiation monitoring, the astronauts observe spectrometer outputs and dosimeter readings daily.

d. In investigations of the physical behavior of selected material samples, a single astronaut is required, using specialized equipment. Activities include the study of capillarity action, gas/vapor equilibrium, fluid density gradients, and crystallization.

e. The deployment and study of large RF reflective structures requires one astronaut for observation and another to maintain a stable vehicle orientation.

f. The determination of the physical and chemical properties of the dust cloud surrounding the earth, requires two astronauts at selected intervals (one for EVA).

g. The development of personnel and cargo transfer operations, requires extensive EVA to provide the astronauts with the opportunity to perfect their operational techniques.

h. The development and study of personal hygiene techniques, and equipment and food technology, require the astronauts to investigate procedures, such as, preparing and eating food, salvage and waste disposal, tooth and gum cleaning, water recovery and other techniques. Operations are often scheduled during normal work periods.

i. The behavioral experiments utilize test apparatus to evaluate sensory and preceptual processes, psychomotor functions, and vigilance. Some tests require two astronauts, one as the subject and the other as observer; in other tests only one astronaut is required.

During each day in mission orbit, the crews activities also include the responsibility of the scientific experiments. Personal functions are performed in the time remaining.

The time distribution for astronaut functions during the first 14 days of Flight A is as follows:

Function	Time Utilization (Percent)
Experiments	23.7
Flight Operations	8.2
Personal	58.4
Unscheduled	9.7
	100.0

The proposed and scheduled experiment times are as follows:

Source-Recommended Experiment Time (45 days)	1699.0 Man-hours
Scheduled Experiment Time	760.1 Man-hours

NOTE

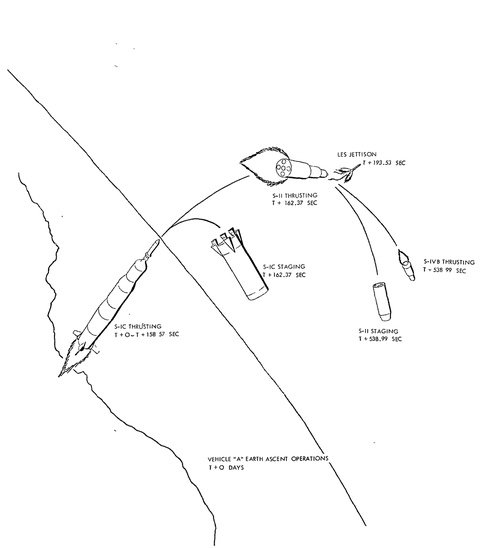
The time distributions of Flight B functions were not determined.

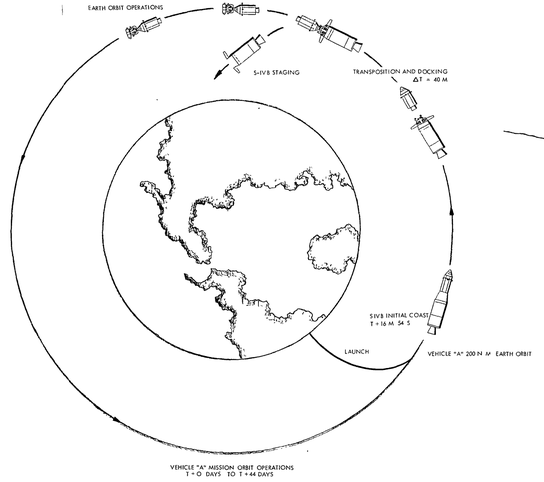
1.5.6 DATA FLOW

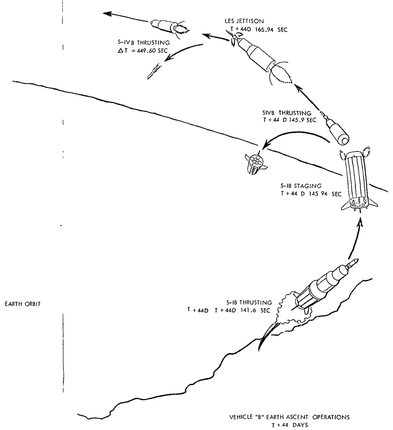
The data flow requirements for Mission 5 include a minimum of 13,904 minutes of transmission time during Flight A, and 5394 minutes during Flight B. Up to six analog and one digital PCM channels could be required for transmission at the same time. Recording activity, however, is well within the presently planned spacecraft data transmission capabilities.

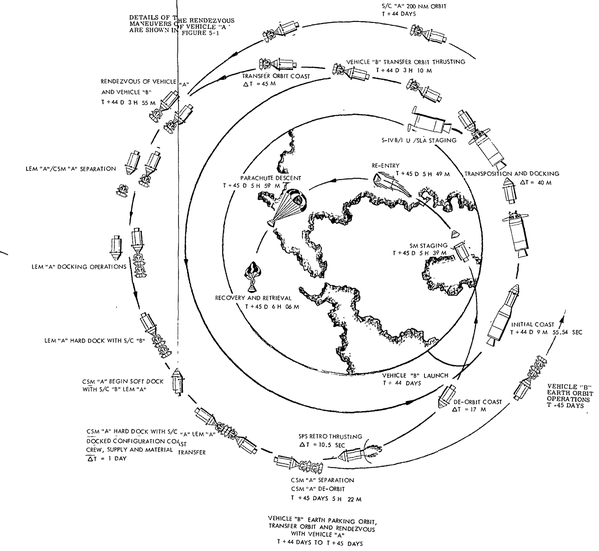
A noncoverage interval greater than 120 minutes will occur on the average of once every three days with the presently planned network of 14 S-band telemetry ground stations.

MISSION 5 S-V/S-1B RENDEZVOUS









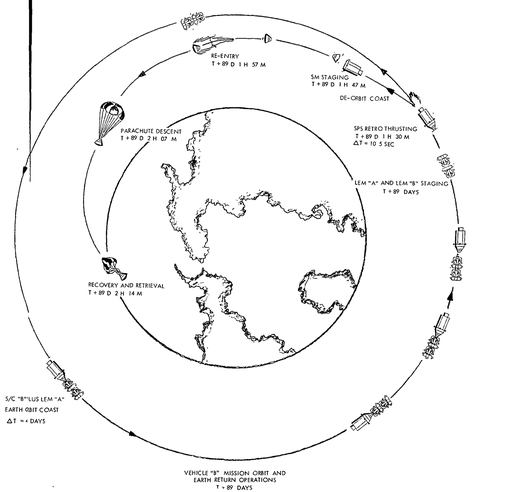


Figure 1-17. Mission 5 - Configuration History

1-61-1

1-61-2

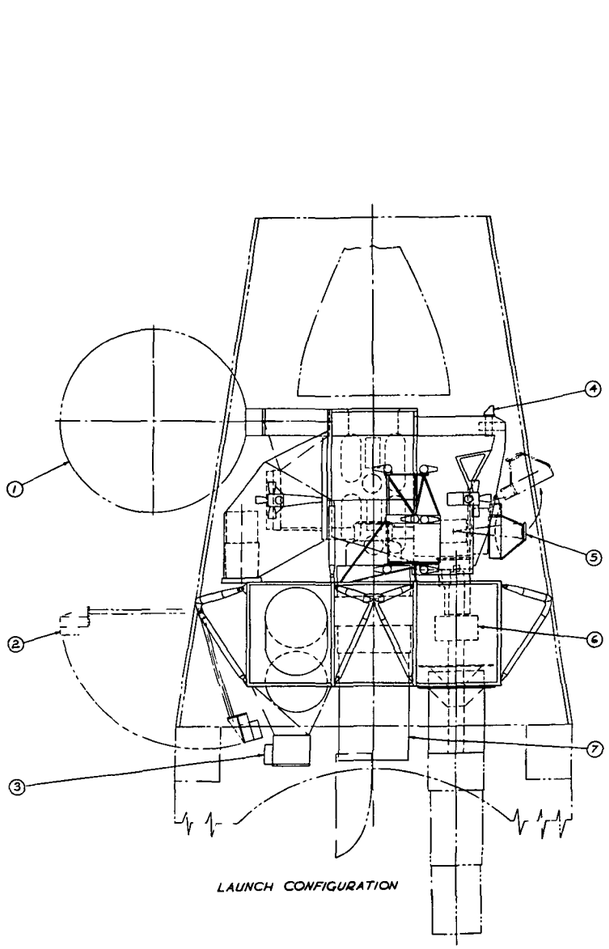
1-61-3

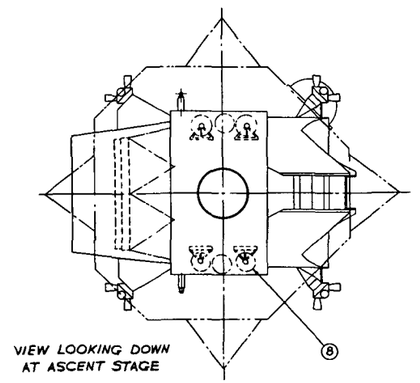
1-61-4

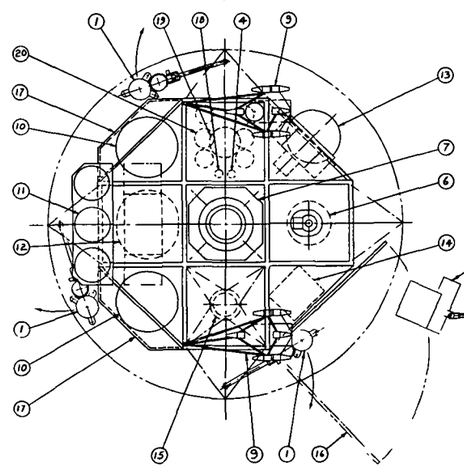
1/1-62

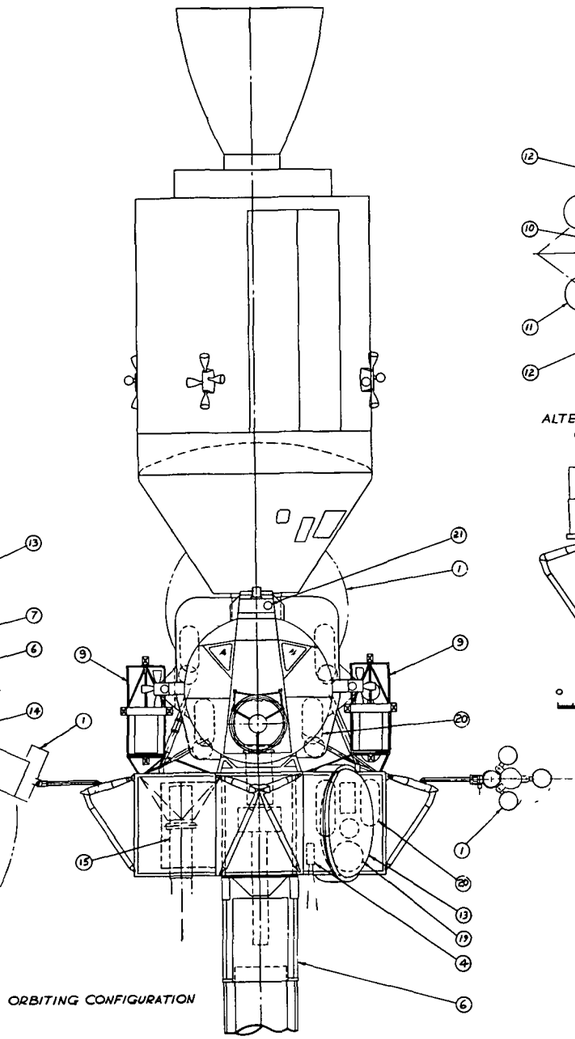
KEY

No.	Experiment	Name
1	0504	Micrometeoroid Collection
2	0606	Cosmic Ray Emulsion
3	0704	Study of Nearly Solar-Like Stars & X-Rays
4		Boresight Star Tracker
5	0605	Crystallization Studies
6	0703	Manned Coronagraph
7	0702	Intermed-Size Reflecting Telescope
8		RCS Fuel
9	0705A	Radio Astronomy 1-5 mc Range
10		H_2
11		FCA
12		O_2
13		
14		External Storage for Exp. 0601, 0602B, 0603A, 0603B, 0604, 0605 & Food.
15	0701	Emission Line Radiometry
16		FCA Radiator
17		Equipment Radiator
18		TV Viewfinder
19		GOX Tank
20		RCS Fuel (D Config. Only)
21		IR Earth Sensor









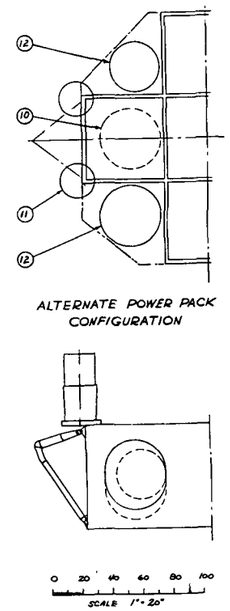
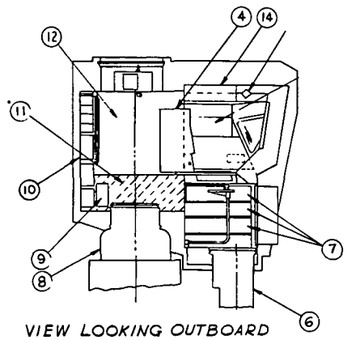


Figure 1-18. Spacecraft Configuration and Experiment Locations Flight A (Sheet 1 of 2) (33 Pages 1-13.38)

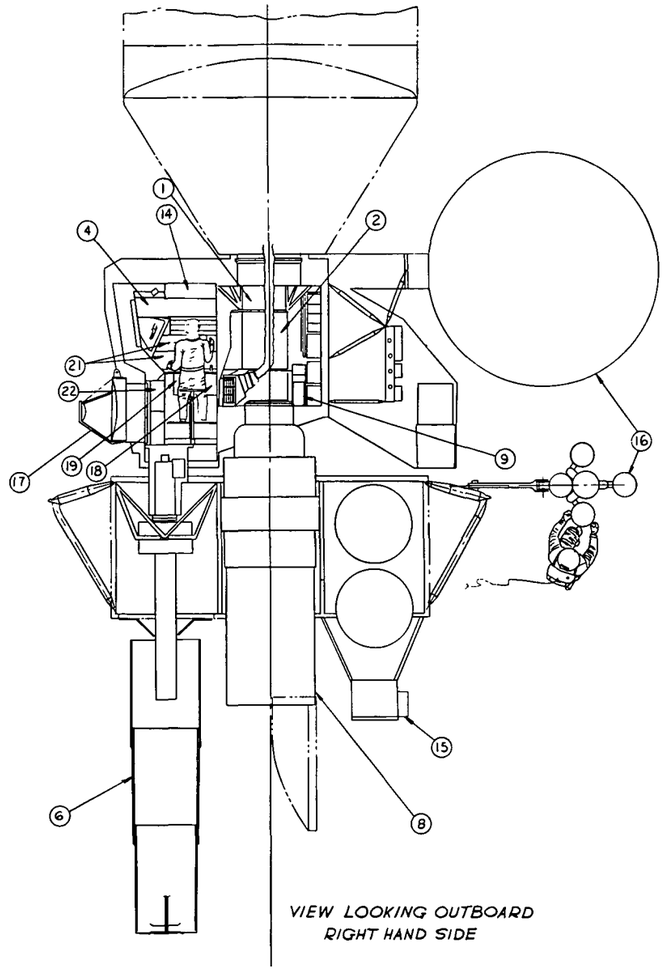
KEY

No.	Experiment	Name
1		Food
2		ECS
3		LiOH (10)
4		Biomed
5		
6	0703	Coronagraph
7		Data Recorder, Log & Data Book, Tape Recorder, Film & Tape Storage
8	0702	Telescope
9	0606	Cosmic Ray Emulsion
10		LGC
11		Equipt. Packages 0601, 0602B, 0603A, 0603B, 0604, & 0605. Held here during experiments. Upon completion will be removed to outside storage.
12	1401	Personnel Hygiene & Food Tech.
13		Floodlights
14	1401	Shower Stowed
15	0704	X-ray Photon Collector
16	0504	Micrometeroid Collection
17	0605	Solar Concentrator
18		Biomed Refrigerator
19		Biomed Incubator
20		
21		Astronomers Display Console
22	0602A	Liquid Drop Dynamics Study
23		Seat and Restraint (2)
24		Bicycle Ergometer
25		Attitude Controller Assy
26		Battery Charger, Pulse Height Analyzer, Tissue Equiv. Ionization Chamber
27		ECS Display Panel & Exp. 0403
28		N&G Display Panel
29	0504	Display Panel

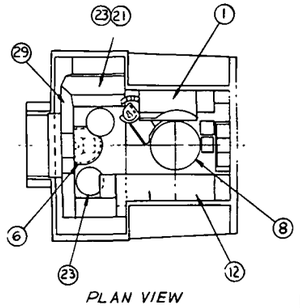


VIEW LOOKING OUTBOARD
LEFT HAND SIDE

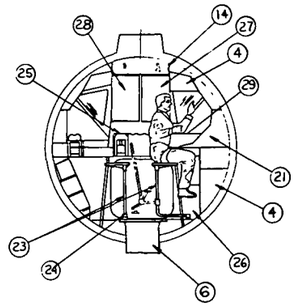
VIEW LOOKING AFT



VIEW LOOKING OUTBOARD
RIGHT HAND SIDE



PLAN VIEW



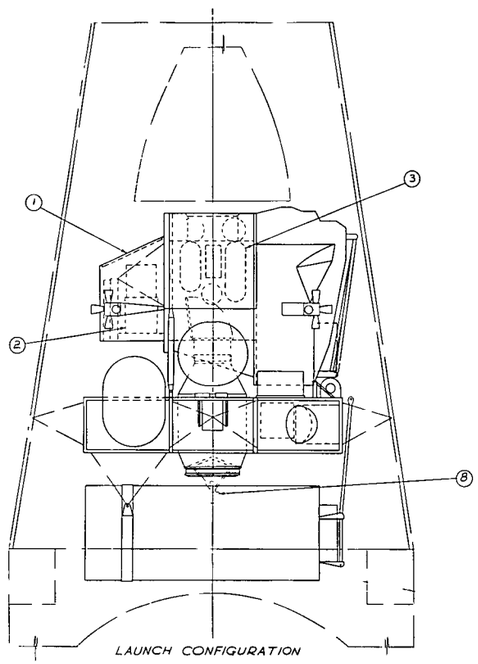
VIEW LOOKING FORWARD

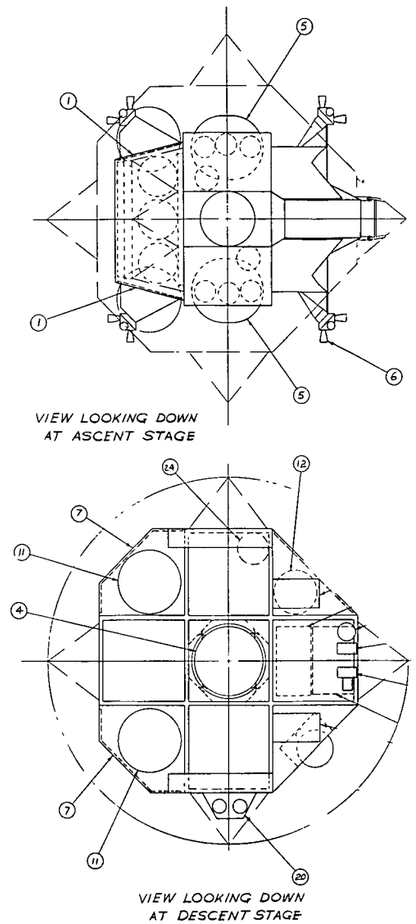
0 20 40 60 80 100

Figure 1-18. Spacecraft Configuration and Experiment Locations Flight A (Sheet 2 of 2) (33 Pages 1-13.39)

KEY

No.	Experiment	Name
1		FCA Radiator
2		FCA
3		RCS Fuel ("D" Config. only)
4		Pressurized Passageway
5		O_2
6		RCS Thrusters ("D" Config. only)
7		Equipt. Radiator
8		Docking Probe (Stored in CM)
11		H_2
12		Water
20	0406	Microorganisms Collection Plates
21		LiOH (36 CM Canisters)
22		Water ("C" Config. only)
23		Flight 13 Lab.
24		GOX Tank





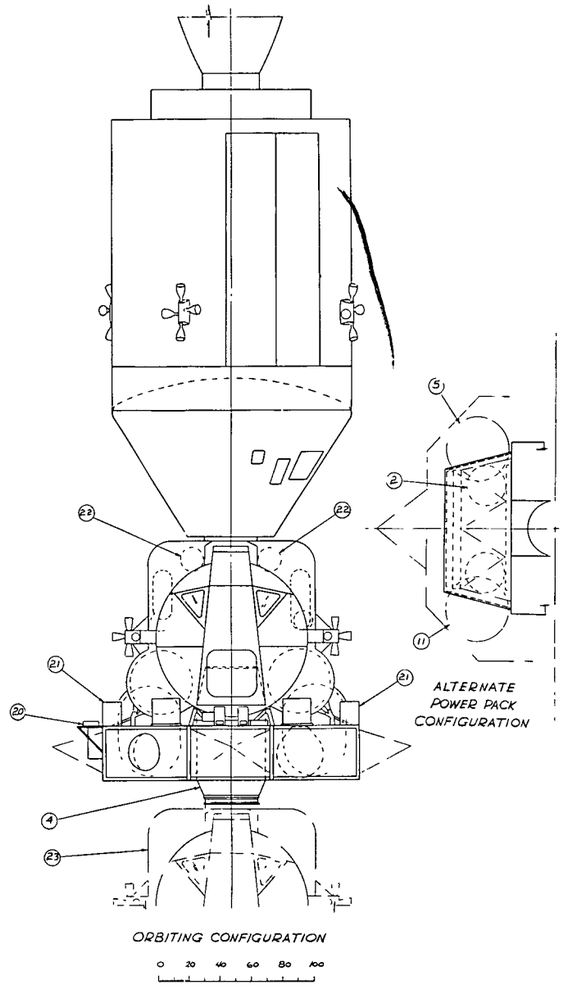
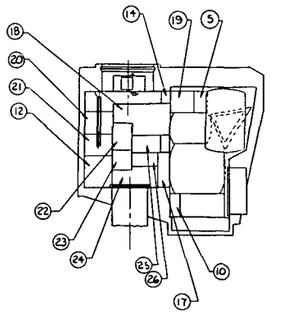


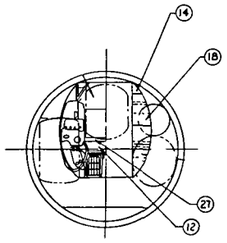
Figure 1-19. Spacecraft Configuration and Experiment Location, Flight B (Sheet 1 of 2) (33 Pages 1-14, 39)

KEY

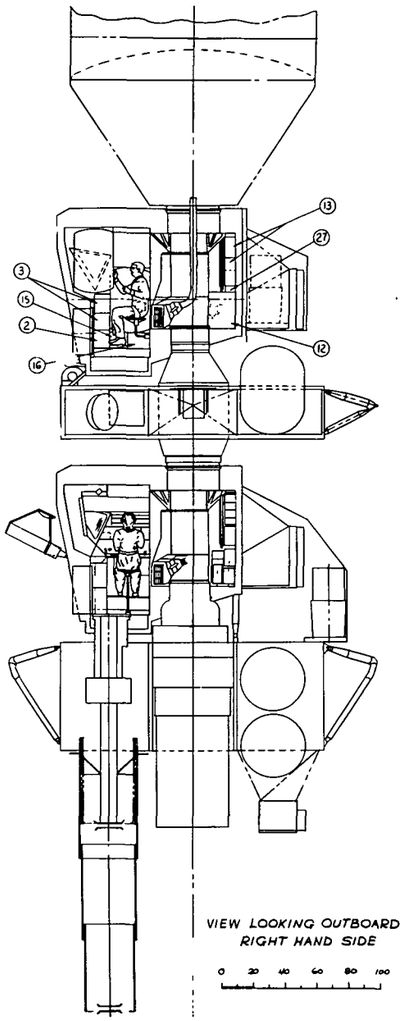
No.	Experiment	Name
1		Film Storage
2	0401&0402	Incubator
3	0406	Incubator
4	0405	Food Storage
5	0404	Equipt. Storage
6	0404	Planaria & Newt
7	0405	Rats
8	0403	Chimpanzee Instr. Panel
9	0403	Chimpanzee
10	0403	Waste & Food Management
11	0400	Freezer
12	0402	-20°C Refrigerator
	0404	
14	0401	Lyophilization
15	0405	Waste Storage
16	0405	Quick Freezer
17	0401	Chemical & Equipt. Storage
18	0402	Culture Flasks
19	0403	Supply Cabinet
20	0406	+5°C Refrigerator
21	0404	-5°C Refrigerator
22	0402	Particle Counter
23	0402	Centrifuge
24	0402	Supply Cabinet & 35mm Camera
25	0402	Scintillation Counter
26	0401,0402 0406	Microscope



VIEW LOOKING OUTBOARD
LEFT HAND SIDE

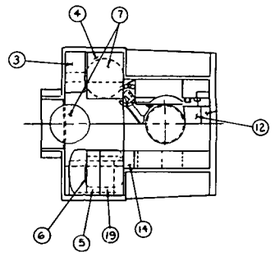


VIEW LOOKING AFT

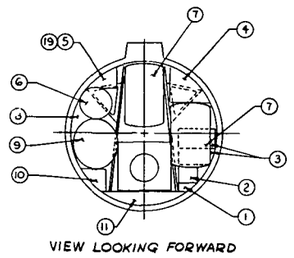


VIEW LOOKING OUTBOARD
RIGHT HAND SIDE

0 20 40 60 80 100



PLAN VIEW



VIEW LOOKING FORWARD

Figure 1-19. Spacecraft Configuration and Experiment Location, Flight B (Sheet 2 of 2) (33 Pages 1-14, 40)

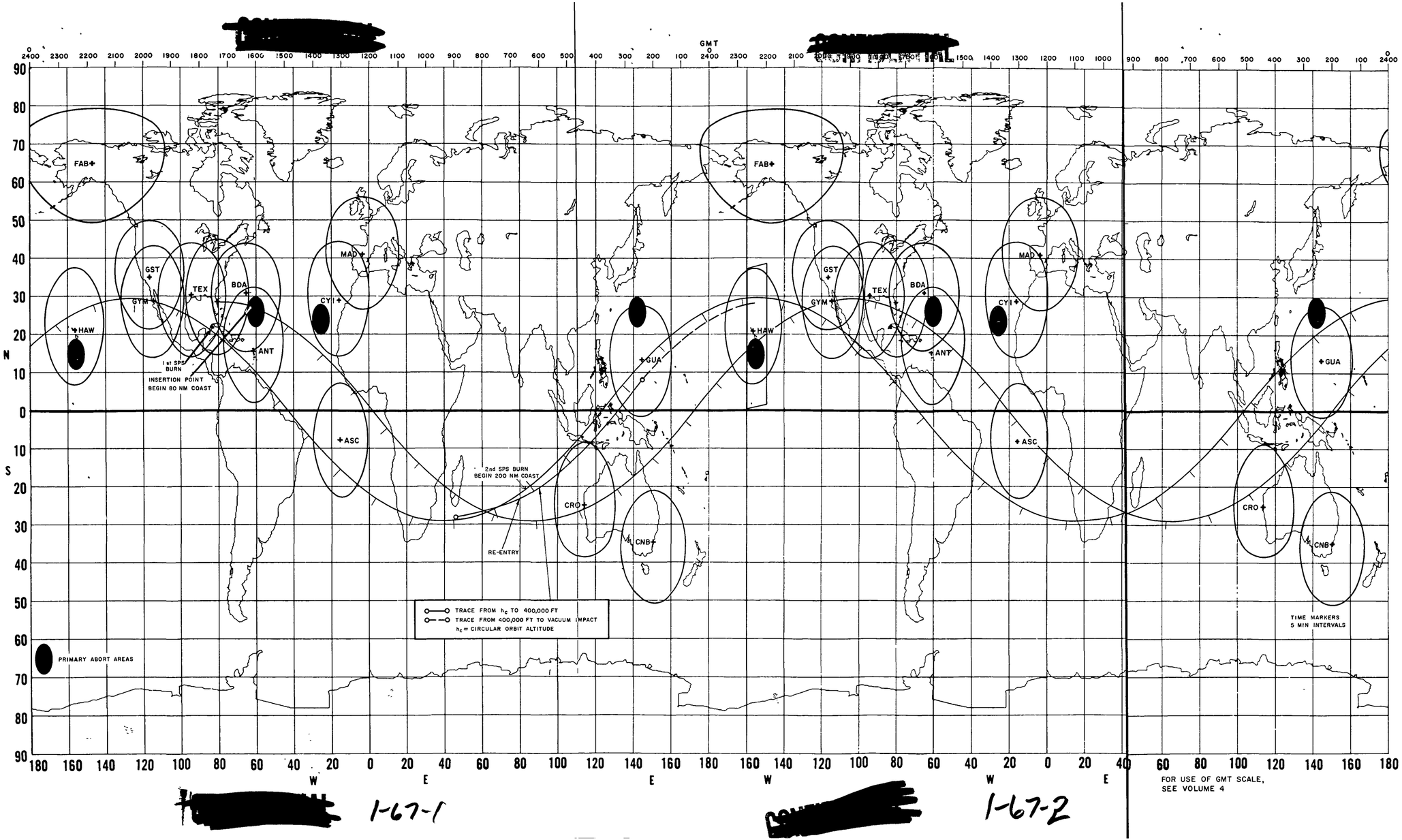


Figure 1-20. Mission 5 - Vehicle B Launch, Insertion, and Re-entry Trajectories

1.6 MISSION 6 - LEM SHELTER/TAXI MISSION

The primary objective of Mission 6, LEM Shelter/Taxi, is a series of lunar surface explorations and experiments. The surface explorations will be based from a LEM shelter, established by an unmanned landing at a preselected landing site on the surface of the moon. For the purposes of this study, Moltke B was chosen as the primary site. After a nominal interval of two months after the landing of the shelter, a manned flight places a LEM taxi, with two crew members, at the shelter site. The navigator remains in the CSM in the lunar parking orbit. After remaining on the lunar surface for 14 days, the LEM taxi crew rendezvous with the CSM in lunar orbit and the CSM and the three crewmen return to earth.

1.6.1 EXPERIMENTS

The lunar surface exploration will gather data to determine the origin and nature of the moon. The types of experiments planned for the exploration of the primary and the alternate sites Moltke B and Alphonsus, and the support equipment required for the experiments are as follows:

Experiment	Support
Topographical survey	Surface mobile vehicle
Geological survey	Life support equipment
Erosion	Data processing equipment
100-foot drill	Power expendables
10-foot drill	Environment experiment panel
Laboratory/LEM	
Gravity survey	
Magnetic survey	
Seismic survey	
Local site survey	
Core hole logging	
Nuclear background survey	
Emplaced scientific station	
Photo and radiometry	
Gas analysis	
X-ray, optical and radio astronomy	
Telluric current measurement	

The location of the lunar sites are shown in Figure 1-21. The exploration details are shown in Figures 1-22 and 1-23.

1.6.2 CONFIGURATION

The configuration history for Mission 6 is shown in Figures 1-24 and 1-25.

The total weight of experiment equipment and associated support equipment varies between 2700 pounds for Alphonsus exploration to 2800 pounds for Moltke B exploration.

For the lunar taxi mission there is no weight margin. The total scheduled spacecraft weight is equal to the maximum weight capability into translunar orbit. The lunar shelter flight has a weight margin of 2614 pounds.

1.6.3 TRAJECTORY

Each flight utilizes a Saturn V vehicle launched from AMR at an azimuth of 90 degrees into a 100-n. mi parking orbit at a 28.5 degree inclination. The trajectory characteristics are as follows:

	First Launch	Second Launch
Translunar Injection Latitude	1.5 degrees south	25.5 degrees south
Translunar Injection Longitude	16 degrees west	38 degrees west
Translunar Injection Velocity	35,840 feet per second	35,860 feet per second
Translunar Flight Time	110 hours	110 hours
Lunar Orbit Insertion ΔV	2590 feet per second	2560 feet per second

The latitudes of the assumed lunar landing sites prescribe a near equatorial lunar parking orbit. The longitudes of the sites indicate that arrival at the moon should take place near the first quarter to satisfy the lighting condition for a lunar landing. Southern injections were chosen for both flights to avoid plane changes during lunar orbit insertion into near equatorial orbits.

1.6.4 OPERATIONS

Translunar injection is executed by the S-IVB stage during the second parking orbit. Spacecraft systems are checked, and the parking orbit ephemeris is determined during the 2-1/2 hours spent in the parking orbit. The spacecraft is injected into a free

return circumlunar orbit with a pericynthion of 80-n. mi. Transposition and docking occurs early in translunar flight and must be completed not later than 6.5 hours mission time. Provision is made for three midcourse corrections. The spacecraft is inserted in lunar parking orbit by the SPS. The parking orbit ephemeris is determined by MSFN and by lunar landmark sightings by the navigator.

1.6.4.1 Flight A

In the first flight the CSM crew monitors the automatic descent of the LEM to the lunar surface. During the two lunar orbits of the CSM, immediately following the LEM descent, the crew locates the touchdown site of the LEM shelter and confirms the successful landing. Upon further ephemeris verification, transearth injection is effected.

1.6.4.2 Flight B

In this flight, after lunar parking orbit confirmation, the commander and engineer descend from the orbiting CSM to the LEM shelter in the LEM taxi. The navigator remains in the CSM. After an exploration period of 14 days on the lunar surface, during which time the CSM remains in lunar orbit, the LEM taxi ascends from the lunar surface and rendezvous with the CSM. The ephemeris is verified and a transearth trajectory is initiated.

1.6.5 CREW ACTIVITY

The activities of the navigator in the orbiting CSM include systems status checks, navigational sightings, and communications with MSFN and the LEM taxi (when line-of-sight conditions permit). The two crew members on the lunar surface maintain communications with MSFN and the CSM.

In each 24-hour period approximately two hours are available for the orbiting crew member to perform experiments. During the 14-day surface mission, the time utilization is as follows:

Function	Time Utilization(Percent)
Shelter Housekeeping and Communications	17
Monitoring	10
Ingress/Egress	4
Surface	17
Shelter Laboratory Experiments	12
Personal	40

A preliminary review of the proposed mission profile reveals that the crew schedule would have allowed insufficient time for rest and sleep, and no time at all for eating and hygiene.

1.6.6 DATA FLOW

Data recording requirements for this mission will probably not return an excess payload. A spacecraft in lunar equatorial orbit is within the line of sight of earth telemetry stations more than 50 percent of the time, and a LEM shelter or LEM taxi on the near-side of the moon is covered continuously.

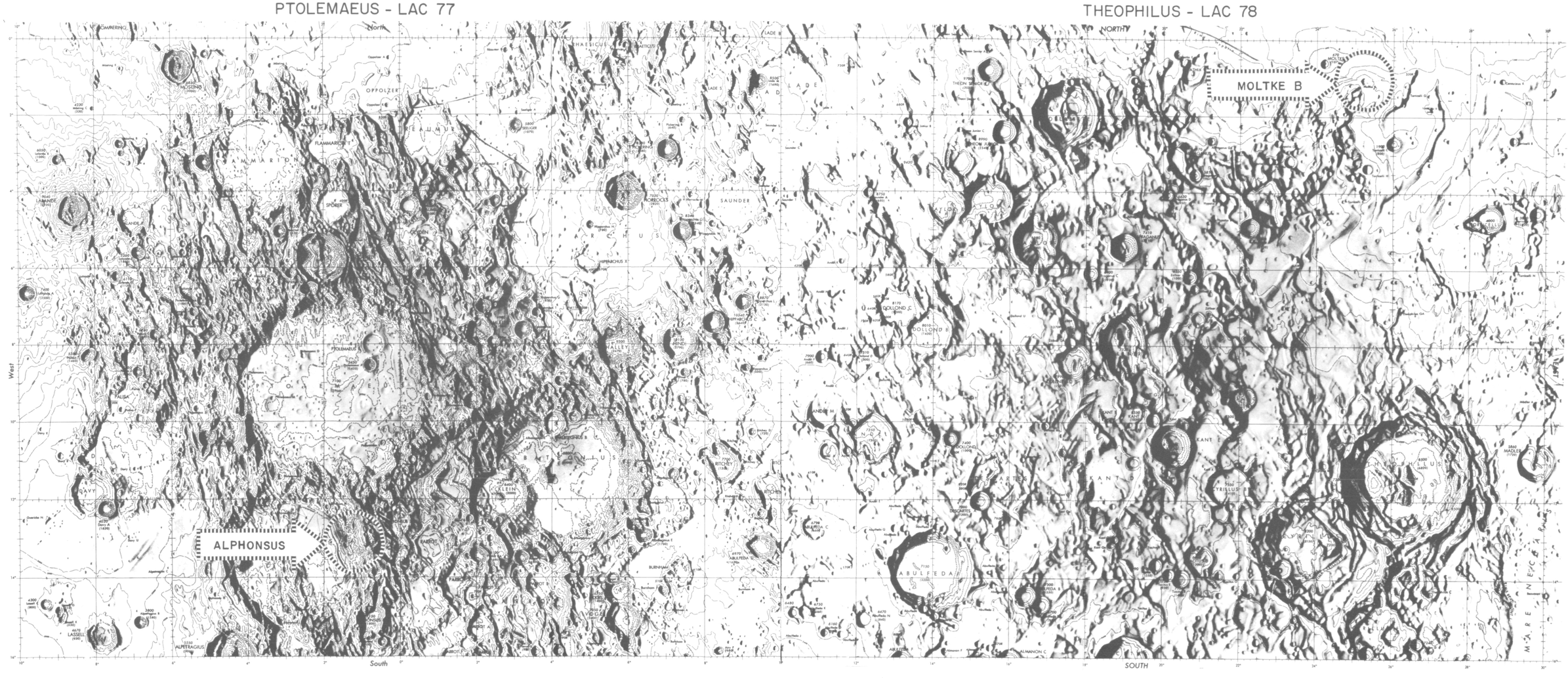
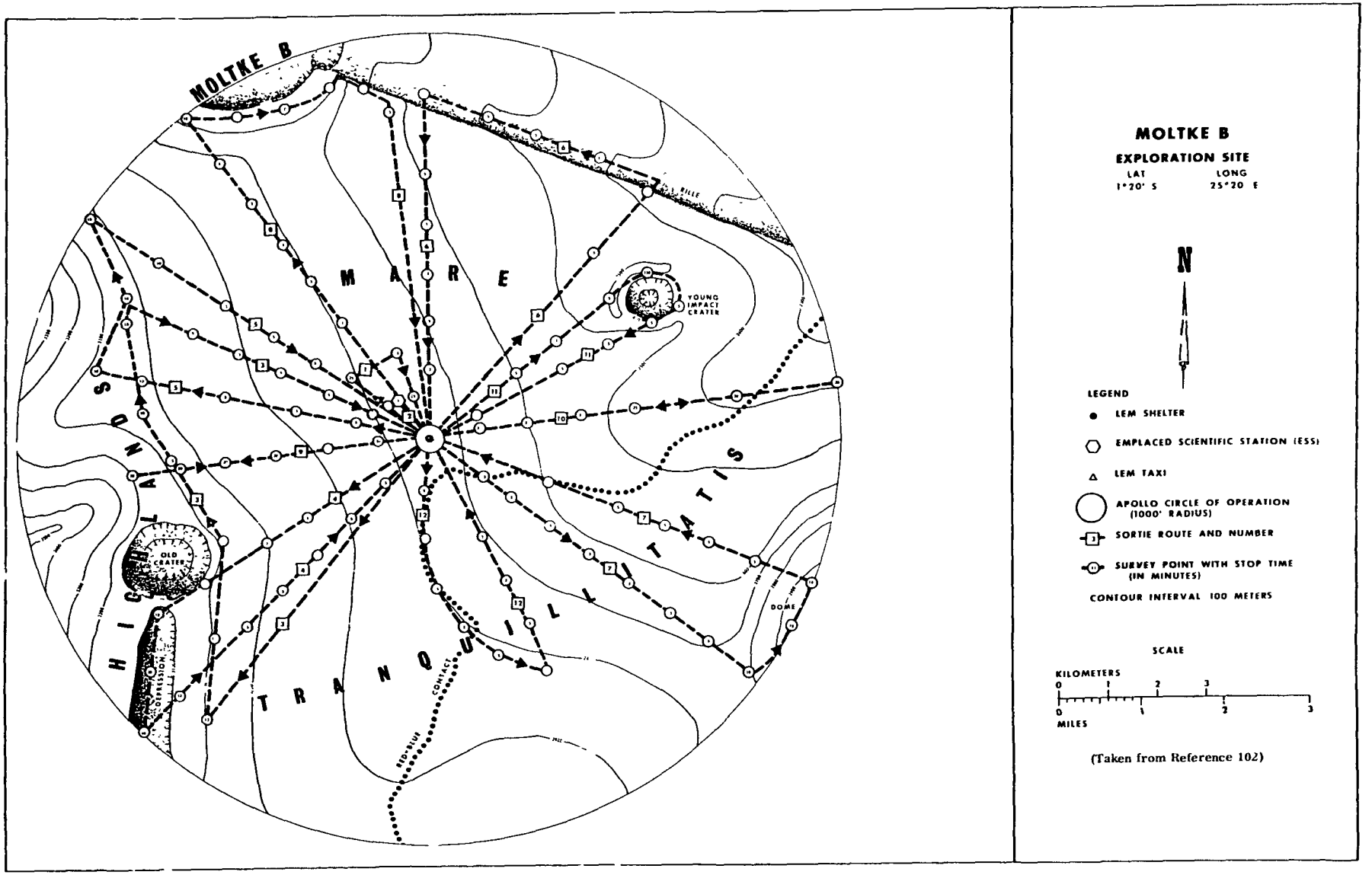
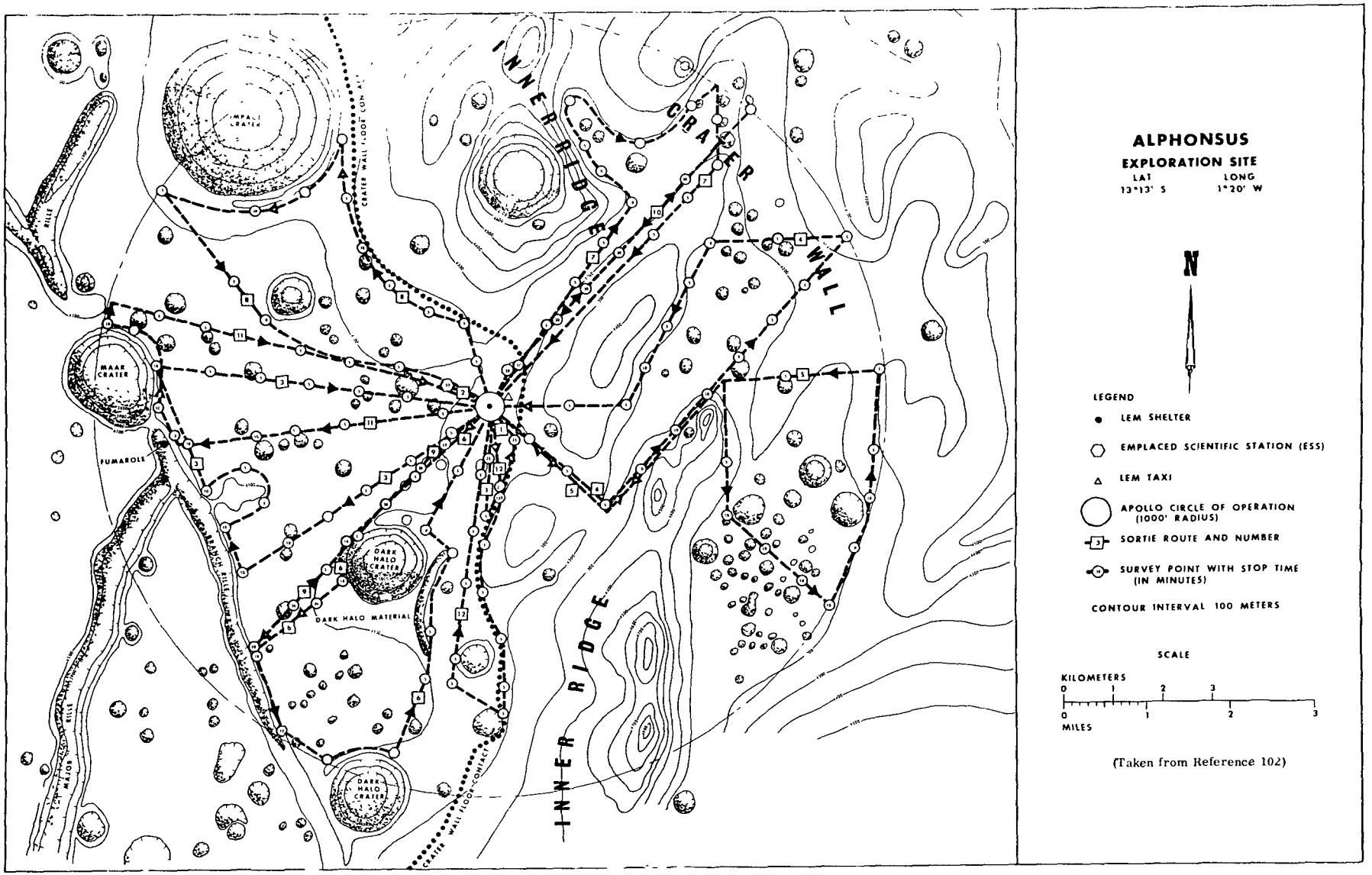


Figure 1-21. Location of Lunar Exploration Sites



(Taken from Reference 102)

Figure 1-22. Moltke B Exploration Site



(Taken from Reference 102)

Figure 1-23. Alphonsus Exploration Site

MISSION 6 LEM SHELTER TAXI MISSION PART A-SHELTER DELIVERY

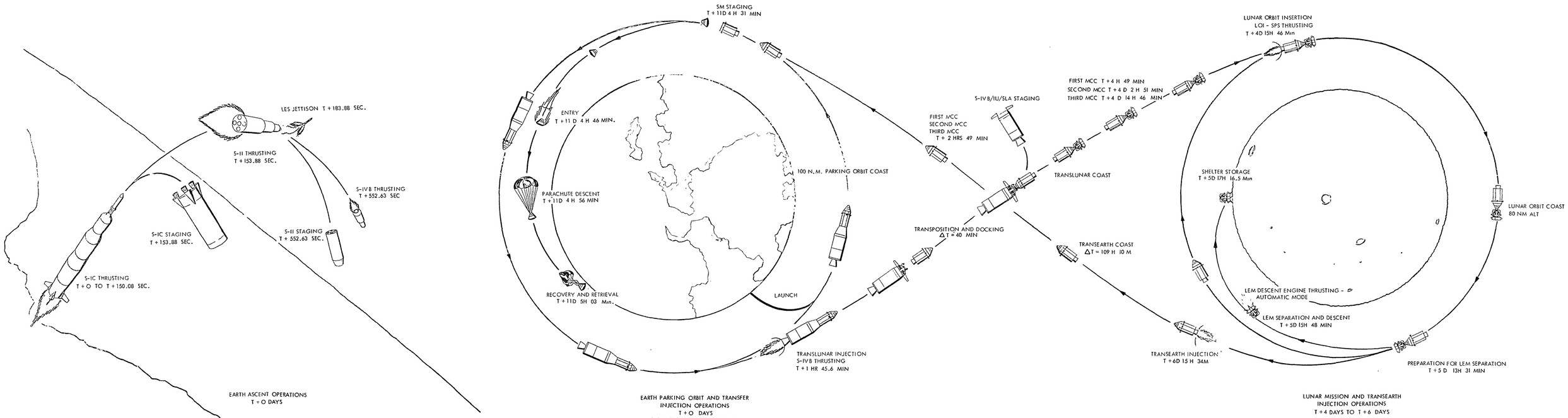


Figure 1-24. Mission 6 - Configuration History

MISSION 6 LEM SHELTER TAXI MISSION PART B-TAXI EXPLORATION

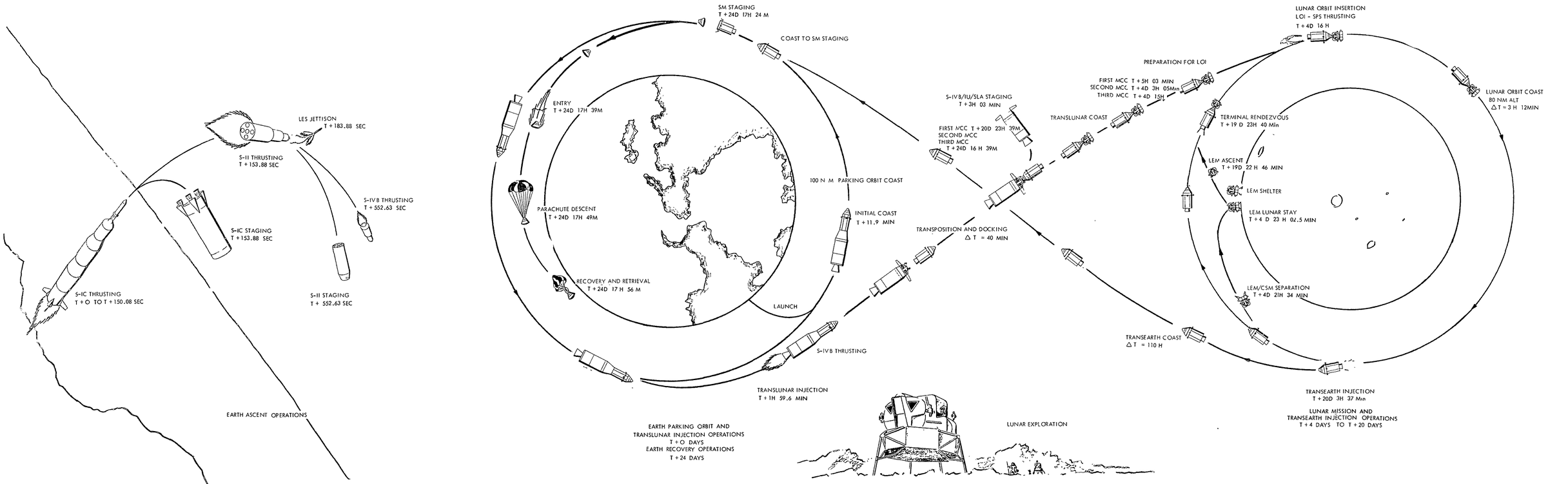


Figure 1-25. Mission 6 - Configuration History

1.7 MISSION 7 - LUNAR POLAR ORBIT SURVEY

The Lunar Polar Orbit Survey mission will photographically map the entire lunar surface. In addition, 138 sites on the near side, 128 sites on the far side, and 100 targets of opportunity will be photographed in detail for site survey purposes. Figure 1-26 shows the sites to be photographed. The lunar mapping period will be 28 days. The lunar orbit will be circular at an altitude of 80 n. mi., and inclined at 90 degrees to the lunar equator. The lunar mapping schedule and site surveys will begin immediately upon insertion into lunar orbit, with mapping accomplished during every sixth orbit. At the conclusion of the 28-day mapping period, the LEM/LAB will be jettisoned in lunar orbit, and the CSM will return to earth.

1.7.1 EXPERIMENTS

During this mission the entire lunar surface will be surveyed using remote sensing equipment. Except for the camera system, information is not presently available concerning the experiment equipment. The mapping camera has a field of view 75-degrees square. Additional site coverage can be obtained by rolling the CSM six degrees or less. The survey camera with a field of view of 10 degrees square, is capable of operation at sun angles from 5-to-55 degrees. The preferred range is 15-to-45 degrees. One-tenth of a pound of film is required for each site.

A candidate list of experiments to be conducted during this mission are as follows:

a. Photographic Investigation:
   (1) Cartographic.
   (2) Panoramic.
   (3) Multispectral.
b. IR Surveying:
   (1) Imaging.
   (2) Spectral Emittance.
c. Passive Microwave:
   (1) Imaging.
   (2) Spectrum.
d. Radio Frequency Reflectivity:
   (1) Remote sensing.
   (2) Geophysical investigation.

e. Radar Altimetry and Surface State:
   (1) Multifrequency, polypolarization.
   (2) Imaging radar.
f. UV Absorption and Luminescence:
   (1) Passive.
   (2) Active.
g. X-ray flourescence.

1.7.2 CONFIGURATION

The configuration history for Mission 7 is shown in Figure 1-27.

The total scheduled weight allotted for experiment equipment at this time is 2936 pounds. The weight margin for the mission, obtained by subtracting the scheduled total spacecraft weight from the maximum weight capability in orbit, is 545 pounds.

1.7.3 TRAJECTORY

Payload weight considerations used in this study require translunar and transearth flight times of 106 hours each, with 28.08 days spent in an 80-n. mi. circular lunar orbit. The arrival longitude at the lunar orbit is 82-degrees west. The far side of the moon will be surveyed first. To maintain adequate latitude coverage while holding the proper sun illumination angle, three equal node shifts of 3 degrees, 20 minutes each are used. These orbital changes rotate the plane of the orbit about the lunar polar axis and are performed over the lunar north pole.

1.7.4 OPERATIONS

Except for the longer flight times, the translunar and transearth mission phases parallel the corresponding Apollo design reference mission phases. For lunar orbit operations the engineer transfers to the LEM. Orbital plane changes are performed on the sixth, eighteenth, and twenty-fifth days in mission orbit, which move the ascending node of the orbit along the lunar equator. The changes are accomplished by SPS thrusting while over the lunar north pole. At the end of the 28-day orbit phase, the engineer deactivates the LEM systems and transfers to the CSM. At this time the crew transfers to the LEM all CM and experiment equipment to be jettisoned. Transearth injection is executed after LEM jettison and CSM orbit ephemeris determination.

1.7.5 CREW ACTIVITY

Flight operation activities required of the crew during lunar polar orbit consist of systems status checks, IMU alignments, and ground communications. The activities parallel those of the design reference mission. Analysis of the flight crew operations and sleep, eating, hygiene, and rest requirements for a typical orbital day, indicate that approximately 19.5 man-hours are available per day to perform experiments. A total of approximately 546 man-hours, therefore, is available for experiments during the 28 days of lunar orbit.

Film recovery will require four EVA's during the mission, including one on the final day in lunar orbit.

1.7.6 DATA FLOW

Recorded magnetic tape probably will not accumulate on this mission because of the availability of coverage. The coverage increases from a minimum of approximately 60 percent to a maximum of 100 percent orbit time as the inclination of the lunar orbit plane with respect to the direction of the earth approaches 90 degrees.

LUNAR SURVEY MISSION
SURVEY SITE LOCATIONS

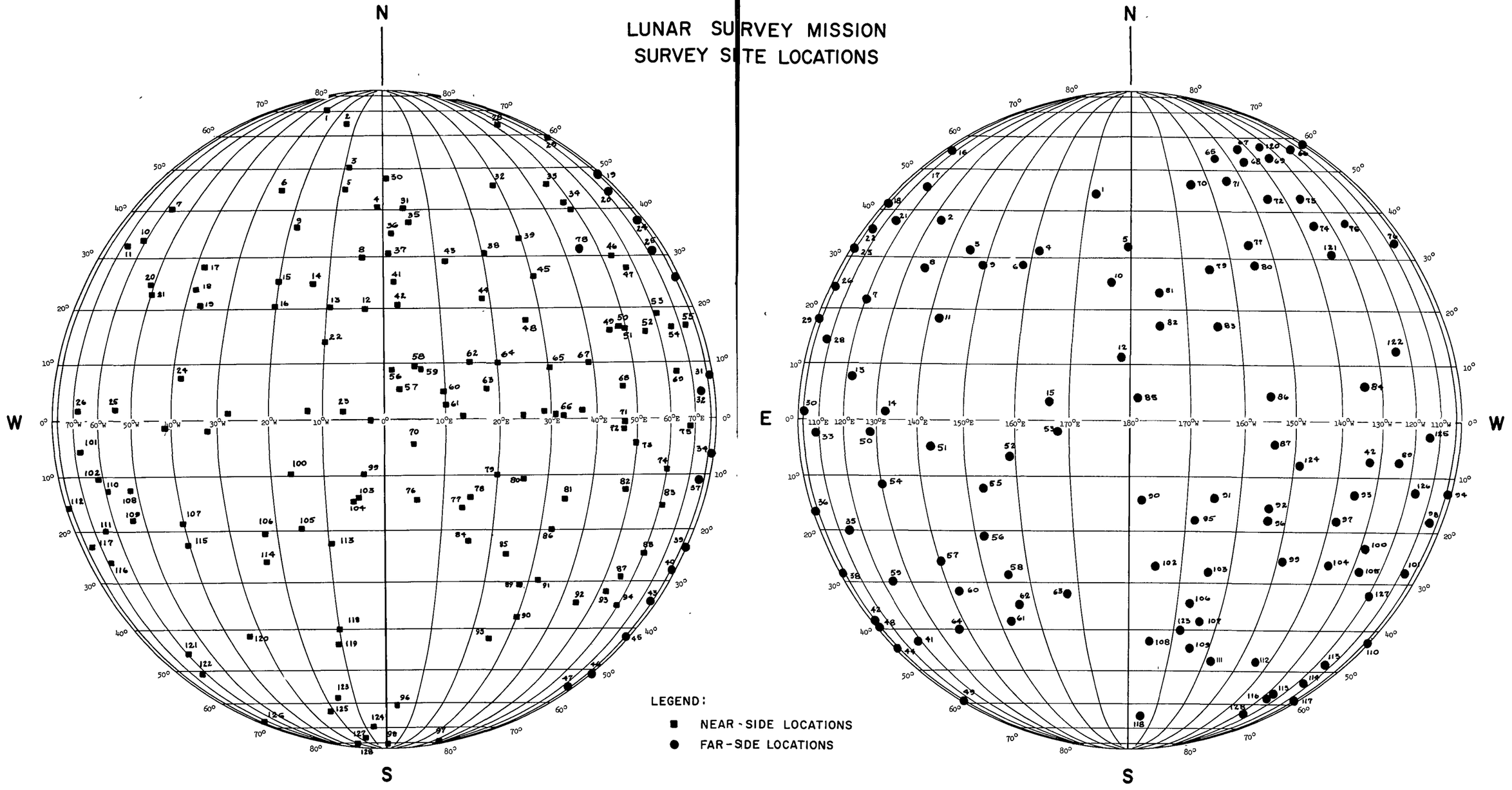


Figure 1-26. Lunar Site Locations

1-83

LUNAR POLAR ORBIT SURVEY

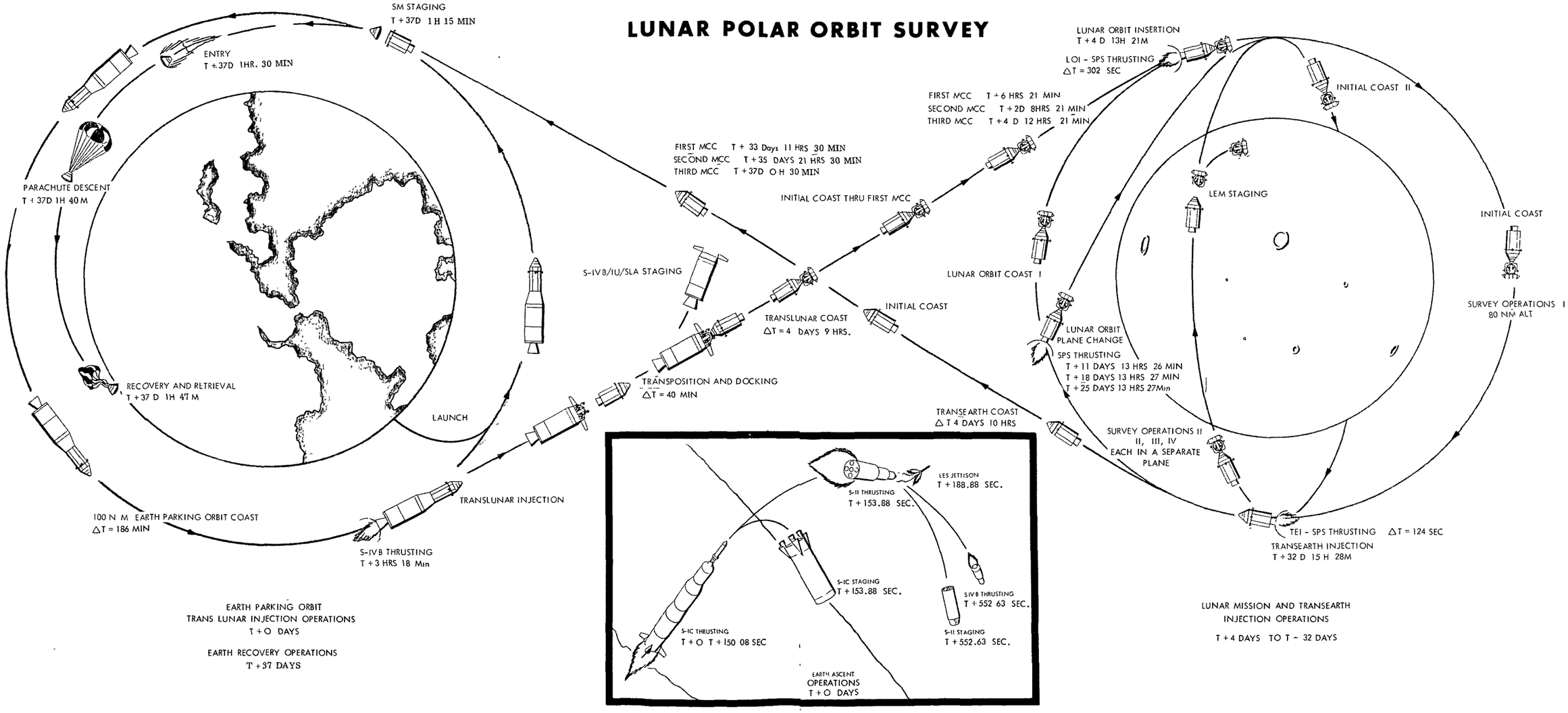


Figure 1-27. Mission 7 – Configuration History

SECTION 2

PROBLEM AREAS AND RECOMMENDATIONS

Planning-related problem areas revealed by this study - and recommendations for solutions to many of the problems - are discussed in the following paragraphs. The most prominent problem areas and recommendations, and those applicable to all Alternate Apollo Missions, are as follows:

a. Experiment Scheduling - Guidelines for assigning relative experiment priorities are required for mission planning. Weight and time limitations, subject availability, and other governing factors in experiment scheduling frequently conflict. The guidelines should dictate prime schedules, alternate schedules, and should provide a base for alterations in real-time when data collection for a particular experiment is impractical. (Lacking priority guidelines, experiment priorities for Missions 1 through 5 were assumed for this study.)

   Extravehicular activity needs further definition in all except the 1500 series of experiments, and more detailed information is required concerning the characteristics of experiment output data and data storage requirements. The source recommended experiment repetitions and number of subjects for the biomedical and behavioral series of experiments cannot be scheduled based on scheduling assumptions and constraints, and should be reviewed. The crew specialties for each mission and the training necessary to reach proficiency should be established.

   The experiment operations requirements for Missions 6 and 7 must be established, and the experiment package make-up of all missions should be re-examined. The Mission 4 package requires an amount of RCS propellant in excess of that available for experiments.

b. Configuration - A programmed thermal control roll mode could be used to alleviate thermal problems except where experiments require specific pointing. Before the use of thermal control roll modes are specified, an investigation of the effects on the performance of experiments, and the interaction with experiment scheduling and RCS requirements, is required.

Shielding must be added to all spacecraft in the tankage areas to provide a 0.99 probability of mission success against meteoroid penetration.

Increased SPS propellant loading should be considered for Mission 3 to minimize drift time. RCS propellant requirements for the flight operations of all missions are undetermined.

The volume and weight constraints on the data payload returnable with the command module are inadequately defined.

c. Trajectory - Increasing the orbital inclination of Mission 1 from 50 degrees to approximately 65 degrees results in coverage by Fairbanks, greatly improved communications, and greatly decreased data accumulation.

Payload weight considerations limit RCS propellant loadings below tank capacities for Missions 2 and 5. This has an undetermined effect on mission operations.

The assumed rendezvous mode for dual-flight missions also requires a detailed re-examination.

The earth parking orbit altitude for Saturn IB missions requires study to balance payloads, stay-times, and operational constraints.

Analysis of the LEM Shelter/Taxi Mission (Mission 6) is hindered by the lack of basic data on the effects of trajectory constraints on mission parameters. Launch opportunities for lunar survey missions are seriously constrained by lunar lighting conditions and trajectory parameters. An immediate and thorough analysis of these constraints is needed over a broad range of launch dates. Lunar missions using non-free return trajectories, high-inclination lunar orbits, and long stay-times present abort situations markedly different from Apollo, and undefined.

d. Data - An extreme accumulation of recorded data occurs on several missions, assuming current Apollo transmittal rates. The data design requirements should be examined to determine the capabilities of simultaneous transmittals of several channels of analog telemetry data, and transmittals of digital telemetry data at much higher rates. Techniques, such as film scanning, data compression, and high density magnetic tape recording, should be studied to reduce the massive accumulation of data.

2.1 MISSION 1

2.1.1 TRAJECTORY

The mission trajectory requires a 44-degree launch azimuth from AMR, which is outside present AMR range safety limits (72 to 108 degrees). A waiver of the limits and careful planning of the S-IC and LES impact points are required.

The experiment constraints on the mission trajectory specify a midwinter or midsummer launch date. The planned launch date (see Table 1) conflicts with the seasonal requirement.

2.1.2 WEIGHTS

The specified 221 pounds of SM RCS propellants available for flight operations might not be adequate for this mission. Although a positive weight margin of 714 pounds is available, additional tankage and accompanying structural weight would exceed the current payload weight constraint. However, if the Saturn IB payload capability is increased, then an increase in SM RCS tank capacity should be considered.

An additional 27 pounds of meteoroid shielding is required to reduce the probability of penetration to an acceptable level (0.99).

2.1.3 CONFIGURATION

Thermal control problems could exist for the RCS nozzle, valves, and tankage in both hot and cold cases if programmed thermal control maneuvers are interrupted for 35 hours or more. Experiment pointing constraints must be relaxed to permit thermal control maneuvers, or the LEM RCS will require design changes.

2.1.4 DATA

The data collection requirements result in a data payload recovery of more than 580 pounds. The assumed recoverable payload capability is only 250 pounds.

With the presently planned telemetry coverage, noncoverage intervals that exceed 120 minutes will occur on the average of once per day. Coverage is not presently available from an assumed Fairbanks, Alaska, station because of a low orbital inclination.

A higher orbital inclination (greater than 60 degrees) would possibly eliminate data payload problems.

2.1.5 CREW TASKS

Astronaut rest time for Mission 1 was reduced one hour a day to permit the maximum scheduling of experiments. Insufficient time (after rest time reduction) required that the 0100 Medical and 0200 Behavioral series be performed on only one subject (the Navigator) instead of the source-recommended three. The requirement that two or more astronauts be concurrently available presents similar problems.

Seven experiments in the medical and behavioral series were dropped, and three were scheduled at fewer frequencies of performance than recommended. These experiments require mission durations of 30 days or more.

2.2 MISSION 2

2.2.1 TRAJECTORY

The orbital altitude decay of Vehicle A because of atmospheric drag is a significant factor in mission planning. The limited Saturn IB payload capability, coupled with a limited stay time in the 80-n. mi. parking orbit, restricts the launch window to 24 minutes. Programmed maneuvers by Vehicle A to maintain the 200-n. mi. mission altitude ease rendezvous phasing problems, but increase the requirement for SPS propellant that Vehicle A must carry into orbit. If Vehicle A is to maintain an orbit altitude of 200-n. mi., the necessary propellant weight must be determined.

Rendezvous techniques in a low-inclination earth orbit should be studied further. The optimum distribution of SPS propellant between vehicles to minimize constraints on rendezvous operation, including the launch window and phasing time, should be established for this mission, along with precise evaluations of weight, propellant, launch-window, and phasing-time parameters.

2.2.2 WEIGHT

Vehicle B is assumed to be the active vehicle in the rendezvous maneuver, and an additional 455 pounds of SPS propellant must be assigned to Vehicle B to provide maneuver capability.

The SM RCS tank capacity (2457 pounds) is larger than the available margin for Vehicles A and B, assuming an increase in the Saturn IB payload capability. Guidelines are not available on the amount of RCS propellant loading. Control for spacecraft operations must be supplied by the SM RCS, which because of margin restraints can be only partially filled. The actual operational requirements for the RCS must be determined.

Additional shielding weights of 152 pounds for Vehicle A and 21 pounds for Vehicle B are required to reduce the probability of meteoroid penetration to an acceptable value (0.99).

2.2.3 EXPERIMENTS

Extensive EVA is undertaken during this mission, but presently available guidelines are insufficient to adequately assess crew requirements. Current experiment guidelines do not consider the continuation of experiments between Flights A and B, and additional

guides are needed. The RCS and cryogenics loads of Flight B must be properly sized to support these continued experiments.

2.2.4 CONFIGURATIONS

The rendezvous and high-gain transponders deleted from the CSM should be restored to the spacecraft to simplify rendezvous requirements.

The CSM temperatures tend to be low for this mission. Cold-temperature problems associated with the LEM can be alleviated by programmed thermal control roll modes. (The time in an arbitrary position should not exceed 35 hours.)

2.2.5 DATA

Telemetry noncoverage intervals greater than 120 minutes can be expected to occur on an average of once every three days.

2.2.6 CREW TASKS

The six-hour sleep periods during this mission are separated by 21 hours, in several instances, resulting from the requirement of experiment 1503 that all astronauts be available concurrently for almost four hours. The time between certain phases of other 1500 experiments was modified to permit higher priority experiments. Insufficient time also required that the frequencies of the medical and behavioral series, and of experiment 0302 be reduced, and that the 0100 and 0200 series be performed on only one subject instead of the recommended three. Though experiments in both the medical and behavioral series should be conducted using the same subject, the experiments were scheduled for alternate subjects, the engineer (medical) and the commander (behavioral). Sequence times were maintained for all experiments except 0115 and 0116, which were run concurrently for a time saving of one hour.

2.2.7 ABORTS

Ground rules should be developed for near-simultaneous aborts of the two spacecraft.

2.3 MISSION 3

2.3.1 TRAJECTORY

The present trajectory requires a third burn of the S-IVB stage to inject the spacecraft into the equatorial synchronous orbit. The injection maneuver operation should be compared using and not using an S-IVB third burn. If the third burn requirement cannot be met, an alternate method must be specified, with a corresponding possible loss in payload.

2.3.2 WEIGHT

The weight margin for this mission is 3742 pounds, assuming that the SM SPS propellant tanks are loaded to capacity at lift-off. Of the SPS propellant capacity, only 17,849 pounds remain for retrothrust and station changes at orbit injection. The 3295 pounds available for the two planned station changes result in long drift times (about 16 degrees longitudinal change per day).

Meteoroid shielding, totaling an additional 815 pounds, is required to reduce the probability of meteoroid penetration to an acceptable value (0.99).

2.3.3 CONFIGURATION

The S-IVB is required to burn three times to place the spacecraft in a synchronous equatorial orbit, but present design specifications permit only a two-burn capability for the S-IVB. The helium repressurization capability must be raised, and the lifetime of the IU in orbit must be extended.

Excessive CSM cooling rates, LEM RCS heating rates, and a long mission duration require a compromise between loss-emissivity insulation, component isolation, and attitude change scheduling for thermal protection and experiment measurements.

2.3.4 DATA

Data collection volume during this mission requires a recoverable payload of over 305 pounds. The available recoverable payload is only 250 pounds.

2.3.5 CREW TASKS

The number of subjects and experiment frequencies recommended for the medical and behavioral series was reduced in favor of higher priority experiments. Additionally, the medical and behavioral series should be performed using the same subject, but an alternate subject was necessary because of time constraints.

2.4 MISSION 4

2.4.1 TRAJECTORY

The available mission trajectory for Mission 4 uses a programmed yaw turn and directs the vehicle over a populated land area (the southern part of Florida), which violates the range safety constraints on AMR launches. The precise locations of S-IC and S-II impact points cannot be determined from available data. (The S-II impact would apparently be off the west coast of South America.)

Shaping the launch vehicle trajectory by yaw-turning is difficult and further analysis is required to establish its practicability. Realistic operating parameters of a yaw-turn trajectory and the impact areas of all stages must be defined.

Improvements in over-all tracking contact time should be investigated. To provide adequate radar tracking coverage for re-entry in the Pacific recovery range, a dual MSFN station is required at Fairbanks, Alaska.

2.4.2 WEIGHTS

The weight margin for the Mission 4 spacecraft is 31, 122 pounds based on the S-IVB structural limits. Additionally, 38, 546 pounds of SPS propellant is aboard with no assigned operational use. Uses for the excess SPS propellant should be devised.

The RCS propellant requirements to perform the experiments aboard this flight total 3779 pounds. Only 3032 pounds are aboard, which is the total capacity of both the SM and LEM RCS tanks. There is a deficiency of 747 pounds of RCS propellant to perform experiment operations. RCS propellant is not available to perform other required maneuvers.

Meteoroid shielding, totaling 224 pounds, is required in the tankage areas for a 0.99 probability against penetration.

2.4.3 CONFIGURATION

Experiment pointing requirements result in a cold temperature problem for the CSM and a hot temperature problem for the LEM RCS. Programmed thermal control roll modes could be used to alleviate the problems.

2.4.4 DATA

An additional dual MSFN station, at Fairbanks, Alaska, will increase the coverage contact time and reduce the required payload recoveries; however, the data collection volume (predominately exposed film) during this mission will still require a recoverable payload of over 2274 pounds. The planned available recoverable data payload is only 250 pounds.

2.4.5 CREW TASKS

Experiment priorities were assumed in order to schedule the mission. Experiments 0901 and 0902 could not be scheduled during all daylight landmass passes of five minutes or more, as specified, because of the daylight constraints of other experiments. (The setup required in experiment 1405 precludes performing experiments 0901 and 0902 during the first day - to present a buildup of magnetic tape - and experiments 1407 and 0802 A, B, C occupy most of days 2 and 3. Experiments 802A, B, C are required twice daily, and experiment 1407 requires five consecutive orbits for each astronaut on days 2, 3, 12 and 13.)

The recommended number of experiment sequences and the number of subjects tested were modified for experiments in the medical and behavorial series. Sequence times were maintained except in experiments 0115 and 0116, where consecutive performance results in a time saving of approximately one hour.

The mission scheduling constraints should be evaluated against assumed changes in the experiment load to produce better defined over-all objectives, data recovery, and operations within design limits.

2.5 MISSION 5

2.5.1 TRAJECTORY

The Mission 5 profile assigns rendezvous maneuver responsibility to Vehicle A, relieving the launch window and propulsion problems for Vehicle B. Vehicle A has an adequate margin for rendezvous maneuvering, but the exact maneuvers have not been optimized, and other aspects of the assignment (crew fatigue, etc.) have not been considered.

The plane change requirement to widen the launch window can be met. Phase angle discrepancies must be countered by altering the relative periods of Vehicles A and B. Two possible modes for accomplishing this, injecting Vehicle A into elliptical orbits, are discussed in Volume 2, Part I, Section 5. Rendezvous techniques, with the vehicle-in-orbit as the maneuvering vehicle, must be further developed. The launch availability and reliability for the Saturn IB vehicle should be established.

2.5.2 WEIGHTS

2.5.2.1 Vehicle A (Saturn V)

The weight margin for Vehicle A is 22,490 pounds, limited by the S-IVB stack limit. A full SPS propellant load is included in the total scheduled weight, and only 2454 pounds are needed for retrothrust and plane changes. The propellant required for rendezvous maneuvers is not defined at this time.

A total of 720 pounds of SM RCS propellant is required to support experiment operations, leaving a remainder of only 1737 pounds. The adequacies of these amounts have not yet been demonstrated.

Meteoroid shielding of 323 pounds is required for Vehicle A.

2.5.2.2 Vehicle B (Saturn IB)

The weight margin of Vehicle B is 1965 pounds based on an estimate of the Saturn IB increased payload capability. Since SPS propellant is not loaded beyond retro requirements, Vehicle A must perform all active maneuvers.

Only 720 pounds, of an SM RCS tank capacity of 2457 pounds, is assumed onboard to support experiment operations. The remaining 1737 pounds could be loaded and used to support flight operations, still allowing 228 pounds of margin.

Meteoroid shielding of 182 pounds is required for Vehicle B.

2.5.3 CONFIGURATION

After the rendezvous and mating of both LEMs, the A CSM may dock only at a 90-degree angle to the LEM. A feasibility investigation is required. The rendezvous and high-gain transponders deleted from the CSM should be restored to simplify rendezvous operations.

The CSM experiences extreme cold temperatures, the LEM RCS extreme hot temperatures. Thermal control roll modes could possibly be used to alleviate the problems.

2.5.4 DATA

As in Mission 2, the presently planned telemetry coverage results in noncoverage intervals greater than 120 minutes an average of once every three days.

2.5.5 EXPERIMENTS

Guidelines for the continuation of experiments from Flight A to Flight B should be defined, and the design and scheduling of experiments should be established within those guidelines. The RCS and cryogenics load for Flight B must be properly sized to support the experiments to be continued between rendezvous flights.

2.5.6 CREW TASKS

The number of subjects and experiment frequencies for the medical and behavioral series were reduced in favor of higher priority experiments because of time constraints.

2.5.7 ABORTS

Ground rules for the near-simultaneous aborts of two spacecraft must be defined.

2.6 MISSION 6

2.6.1 TRAJECTORIES

The earth-moon trajectories have similar characteristics to the Apollo design reference trajectory; consequently, high-latitude landing site requirements, continuous abort factors, and other trajectory considerations that are not a part of Apollo mission plans are vague. These characteristics, the trajectory and guidance modes for the automatic landing of the LEM shelter and the landing and launch of the LEM taxi require definition.

2.6.2 WEIGHTS

The margins for both the LEM shelter and LEM taxi are based on the payload injection capability of the Saturn V into a translunar trajectory. The weight margin at earth launch for the LEM shelter flight is 2614 pounds, but this margin is not available as lunar surface payload because of design limitations of the LEM descent engine.

The experiment package defined for the Moltke B exploration site is 324 pounds over the experiment weight limit. The experiment package for the alternate (Alphonsus) mission is 280 pounds over the weight limit.

Meteroid shielding totaling 494 pounds is required for the LEM shelter flight; 61 pounds is required for the LEM taxi flight.

The weight margin for the LEM taxi flight is zero, as a result of the deletion of 665 pounds of SM SPS fuel. The remaining SPS fuel should be sufficient for the flight, but further study is indicated.

Definitions are required for sizes, weights, and stowage of samples to be returned from the lunar surface aboard the LEM taxi.

2.6.3 CONFIGURATION

Definitions are required for the LEM shelter automatic landing equipment and the CSM that delivers it to lunar orbit. Emplacement methods for electronic gear at a site, if such equipment is necessary to assist the LEM shelter landing, are undefined. A complete configuration/experiment integration analysis is required for each flight.

The deleted rendezvous and high-gain transponders necessary to effect rendezvous with the LEM taxi should be restored.

Experiments to be delivered to the lunar surface by the LEM taxi are undefined. The total available weight allowance is approximately 80 pounds.

Extreme heat loads exist in the lunar orbit coast period that cannot be solved by a programmed thermal control roll mode for the CSM in lunar orbit. A thorough study of lunar orbit coast heat loads is required. If excessive water boiling is expected, the ECS radiators must be redesigned. (The CM attitude cannot be changed to a more favorable position.)

Equally severe thermal loads exist for the LEM/LAB on the lunar surface. There are three approaches to a solution:

a. Redesign of the LEM thermal shield/insulation system to provide the required vehicle thermal response characteristics.
b. The addition of active thermal control systems to absorb the large positive and negative heat loads admitted by the present insulation system.
c. Periodic attitude changes that can be scheduled without compromising other operational requirements.

2.6.4 CREW TASKS

Complete time-line analyses are not available for setting up, conducting, and stowing experiments, equipment, and samples on the lunar surface. Realistic schedules and crew tasks for the orbiting crewman and the exploration team on the lunar surface must be constructed. The use of manned roving surface vehicles for lunar exploration must also be defined.

2.6.5 ABORTS

A complete definition of lunar surface aborts is required for both flights of this mission.

2.7 MISSION 7

2.7.1 TRAJECTORIES

The complete earth-moon trajectory characteristics are required to determine the effects of the trajectory on site coverage scheduling. The sites must be identified for the scheduled coverage within lunar longitudes 90 degrees west and 180 degrees west.

At least one nodal shift of approximately 10 degrees is required to provide optimum illumination angles on the identified lunar sites scheduled for photographing with the survey camera; three nodal shifts of approximately 3.3 degrees each yield better results. This requirement cannot be satisfied, however, within the available SPS propulsion capability without relaxing the 10 percent ΔV margin constraint.

2.7.2 WEIGHTS

The weight margin for Mission 7 is 545 pounds, based on the payload injection capability of the Saturn V into the translunar trajectory. (The margin is not available as SM SPS propellant; the SM tanks are loaded to capacity at liftoff.)

The meteoroid shielding required for a 0.99 success probability is 326 pounds.

2.7.3 CONFIGURATION

The total weight of the candidate experiment payload for Mission 7 is 4888 pounds. Only 3781 pounds can be budgeted to experiment weight without exceeding the maximum. Priorities for particular experiments must be assigned. A LEM descent propulsion system is retained in the LEM/LAB configuration; however, guidelines have not been established to define the system use.

For the lunar orbit coast period, extreme hot and cold temperature problems exist that cannot be solved by programmed thermal control roll modes. Thermal control methods and provisions must be established to alleviate the problems.

2.7.4 EXPERIMENTS

Two conflicting ground rules for photographic coverage were specified:

a. The overlap of the mapping cameras will be at least 10 percent, but will be as little over this value as possible. This constraint is satisfied by utilizing the mapping cameras every sixth orbit.

b. All film must be exposed during the mission. This conflict arises because the remaining film weight is enough to utilize the camera on every orbital pass over the illuminated lunar surface.

2.7.5 DATA

The data collection requirements for the lunar surface experiments must be defined.

2.7.6 CREW TASKS

Crew tasks have been defined only for the operation of the mapping and survey cameras. The man/machine requirements for identification of targets of opportunity need complete definition, and the remainder of the experiments require a crew task analysis.

2.7.7 ABORTS

The abort capability for a polar lunar orbit should be investigated, and a complete abort analysis should be performed.

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ACRONYMS AND ABBREVIATIONS

AAM	Alternate Apollo Missions
CM	Command Module
CSM	Command and Service Modules
DRM	Apollo Design Reference Mission
EVA	Extravehicular Activity
GAEC	Grumman Aircraft Engineering Company
IMU	Inertial Measurement Unit
LEM	Lunar Excursion Module
LEM/LAB	Modified LEM
LES	Launch Escape System
LiOH	Lithium Hydroxide
MSFN	Manned Space Flight Network
NAA	North American Aviation
PCM	Pulse Code Modulation
RCS	Reaction Control System
SLA	Spacecraft LEM Adapter
SM	Service Module
SPS	Service Module Propulsion